March 7, 1911.

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POWER

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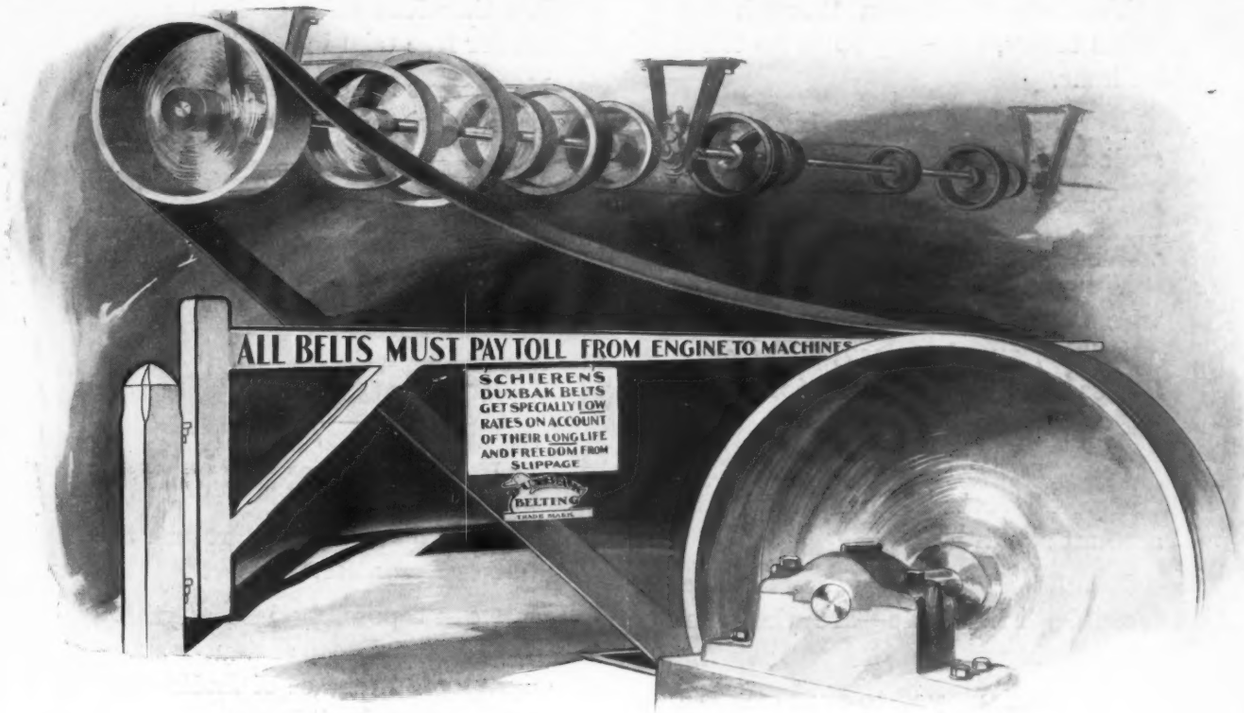
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Dean results are prompt and positive.

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Tomorrow, when you steam up, you find the boilers steaming better.

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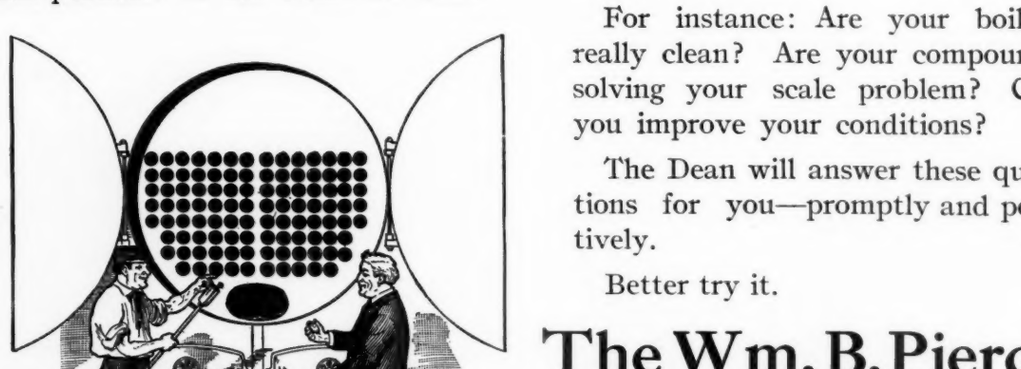
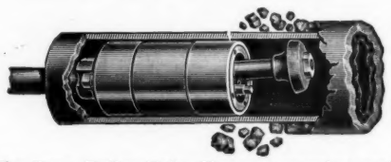
Before asking you to even consider the purchase of the Dean we want to show you exactly what it will accomplish.

We therefore offer to loan you a Dean for free trial in one boiler.

No charges for the trial, no obligations, no strings of any kind.



The Dean Boiler Tube Cleaner removing scale from the tube of a water tube boiler.



The Dean Boiler Tube Cleaner removing scale from the tube of a return tubular boiler.

If you don't get results, return the tool at our expense.

You can't possibly lose anything by trying the Dean and you stand a mighty good chance of finding out something you don't know.

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The Dean will answer these questions for you—promptly and positively.

Better try it.

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POWER

NEW YORK, MARCH 7, 1911

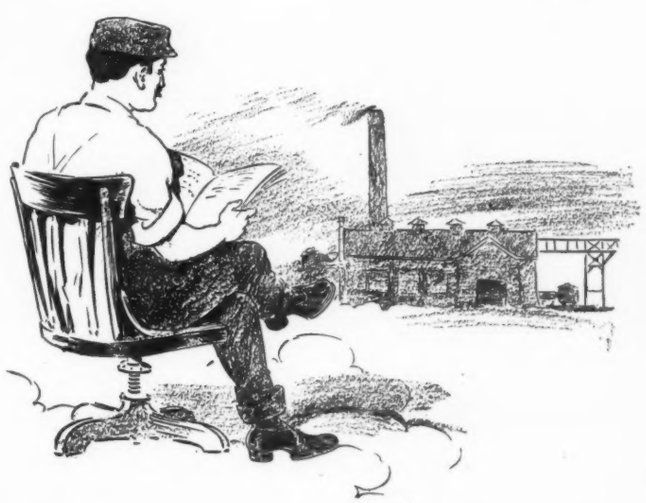
When the hotel owner with one glass eye returned to his establishment after his first trip through the land in ten years, he remarked to the steward that anyone with even half an eye should be able to see that many things in the said establishment were "all to the bad," or words to that effect.

Things were not by far as uptodate as they should be. The steward had evidently been "asleep at the switch."

For one thing, why had not the steward looked up the suitability of a set of those new Marks-Davis steam tables for use in the restaurant kitchens? He of the one eye had discovered that they gave more heat per pound of steam than the old Peabody type.

Most emphatically, things would have to be watched more carefully in the future, else there would be a new steward on the job.

Now, the steward had no excuse to offer. His trouble was that he stuck too close to actual business to be an all-round big success. He bothered personally with too many details, most of which should have been entrusted to suitably selected subordinates. The result was that while he was always busy "stewarding" he wasn't getting the results that he should. He never had time in which to look around and see what progress others were making.



Engineers are troubled with this same complaint. Partly the engineers themselves, are to blame, and partly the employers.

When an engineer's horizon extends only as far as the walls of his plant it is a fairly safe wager that he is not and never will be of very great caliber.

Unquestionably, many an employer could make a profitable investment by sending his engineer out on a trip of discovery to plants similar to his own, say, once a year. Such a trip would be a mental tonic for the engineer, giving him a different point of view of his plant and imbuing him with new ideas to be used to advantage in the future.

The engineer, himself, should get outside of his plant as much as possible on his own "hook." By that we mean that he should do some outside reading and studying bearing on his line of work, should take advantage of every legitimate opportunity to see neighboring plants and should talk with other engineers and with salesmen that happen to call on him.

Try to see your plant as others see it—see its defects and its weak points as well as its strong ones.

A Modern Blast Furnace Equipment

By A. R. Maujer

The Empire Steel and Iron Company has recently made some extensive changes in the equipment of its blast furnace at Oxford Furnace, N. J. Chief among the several interesting pieces of new apparatus is the steam turbine-driven centrifugal air compressor, built by the General Electric Company, which is used to furnish the air blast for the furnace. Next, is the highly efficient barometric condenser. And third, is the radial-brick chimney which is successfully withstanding continuous high temperature.

The most interesting features are a constant-volume turbine-driven centrifugal air compressor, a barometric injector condenser which produces a vacuum of over 28 inches and a single-wall radial-brick chimney which is withstanding temperatures up to 1400 degrees. The suction line for the condensing water is made with welded and Van Stone joints.

A general view of the plant is offered in Fig. 1. The large, square brick building in the foreground is the old blowing-engine house. The brick extension upon the left contains the new compressor. The boilers which furnish steam for the compressor and auxiliary apparatus are just back of this building. The boiler equipment consists of three 300-horsepower Babcock & Wilcox boilers and two 200-horsepower Wheeler vertical boilers. The former are served by the big brick chimney and the latter by the two short steel stacks, shown in Fig. 1, extending a little above the roof line. Steam is generated at 140 pounds gage pressure. Blast-furnace gas is the fuel used under the boilers.

The brick chimney also serves the four 20x80-foot two-pass stoves, which stand back of it. Beyond the stoves is the blast furnace itself, 80 feet high, 17 feet 6 inches in diameter at the bosh and 11 feet at the hearth. Its average production is 200 tons of pig iron in 24 hours.

Centrifugal Compressor

Until the centrifugal air compressor, shown in Fig. 2, was installed and put into service at Oxford Furnace, the air blast for all of the blast furnaces in this country was furnished by reciprocating compressors, or blowing engines, either steam or gas driven.

The two engines at Oxford Furnace which formerly furnished the air blast are typical of the majority of the steam-driven blowing engines at present in use. They are of the single-cylinder long-crosshead steeple type. The steam cylinder, which is below the air cylinder, is 54 inches in diameter; the air cylinder is 72 inches in diameter with a stroke of 72 inches. There are two large flywheels, one on either side of the engine. The connecting rod for each wheel is on the outside; hence, the crosshead extends from one side of the frame clear to the other. Normally the engines ran at 26 revolutions and each furnished 8000 cubic feet of air per minute. The maximum combined capacity of the two engines is 20,000 cubic feet.

The centrifugal compressor has a rated

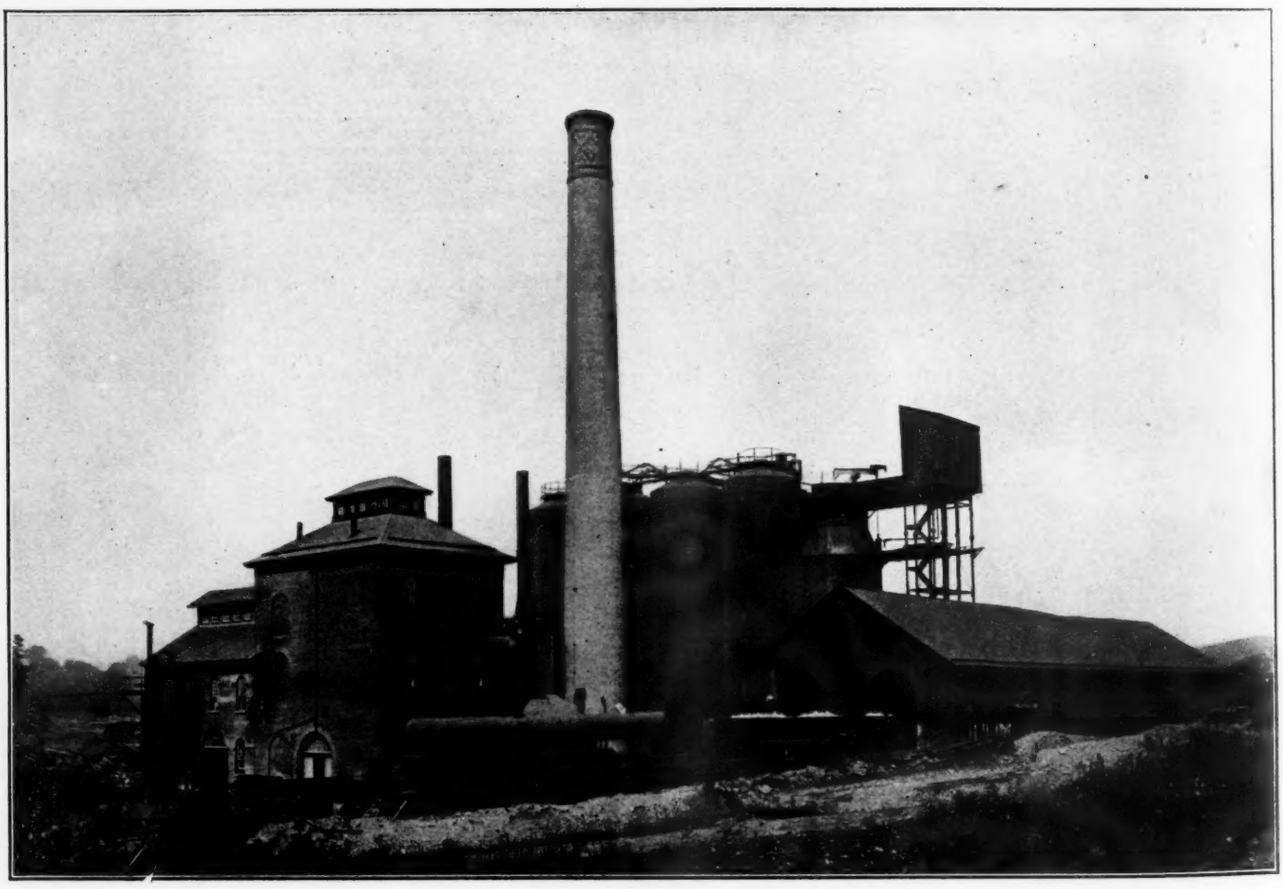


Fig. 1. General View of Oxford Furnace Plant of Empire Steel and Iron Company

capacity of 22,500 cubic feet of air per minute, but at present it is handling only about 17,000 cubic feet. The normal speed of the machine is 1650 revolutions per minute and the normal discharge pressure is 15 pounds per square inch. The pressure varies, however, with the operation of the furnace, the compressor being regulated to deliver a fixed quantity of air at a variable pressure. The compressor has six stages, each of which contains a disk on which are mounted steel blades or vanes. The disks are separated by water-cooled diaphragms. diaphragms between stages, is water cooled; the cooling-water jets and intake pipes are above the casing, as shown in Fig. 2, where they are in plain sight of the operator.

The driving end of the unit consists of a Curtis horizontal four-stage steam turbine. The impeller disks of the compressor are so designed that there is no unbalanced end thrust; hence, the ordinary means used in the Curtis turbine for locating the rotating elements and preserving the proper clearances are sufficient for the entire apparatus.

from the bearings and cylinder to a tank where it is settled and strained before reüse. As a precaution against any stoppage of circulation, an alarm is provided which causes a steam whistle to blow when the oil pressure falls to 5 pounds per square inch. The oil is cooled in the bearings at the point where the heat is generated by means of water-cooled coils, embedded in the bearing linings.

When delivering 22,500 cubic feet of air per minute against a pressure of 15 pounds per square inch, the turbine runs at a speed of 1650 revolutions per min-

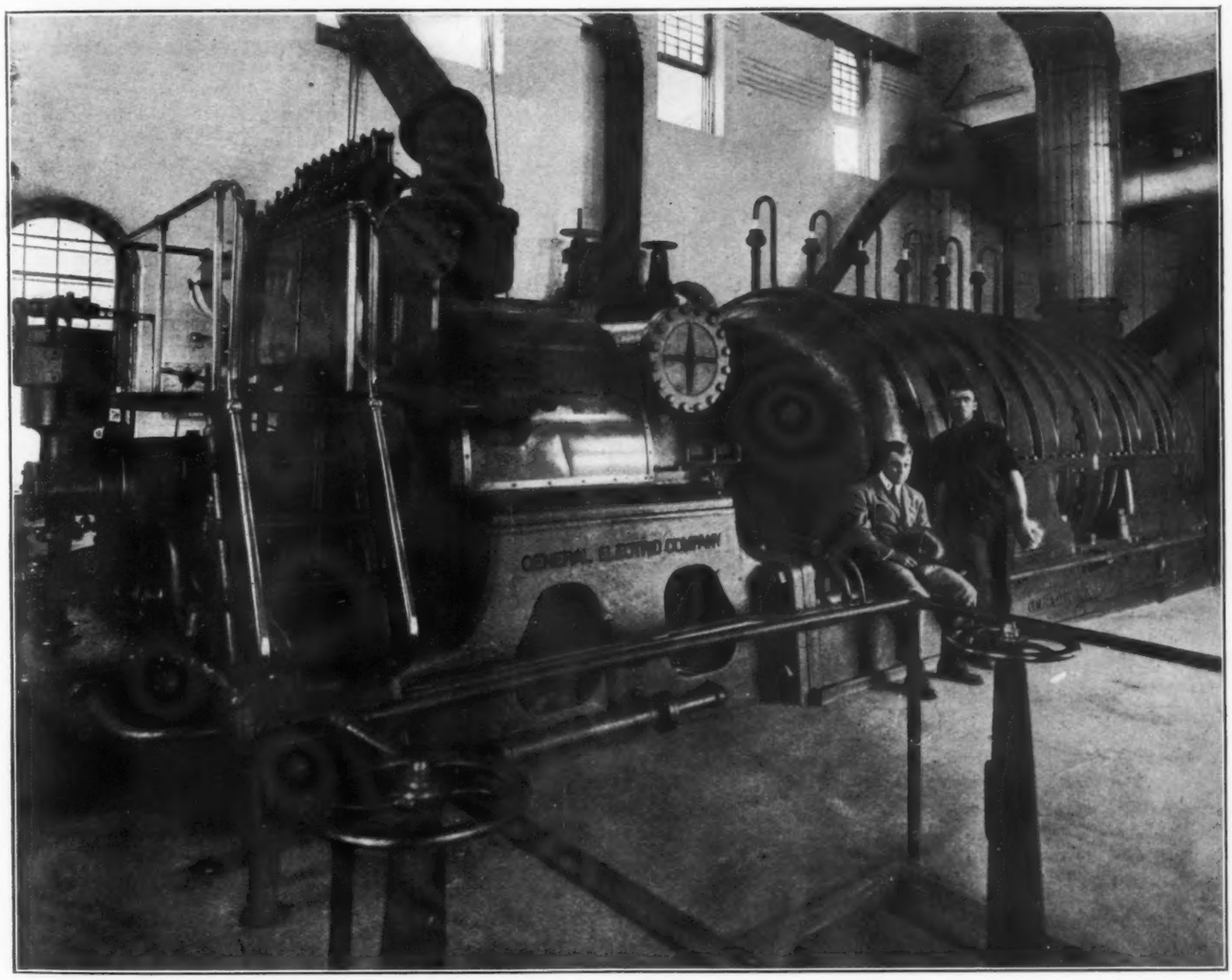


FIG. 2. THE TURBINE-DRIVEN CENTRIFUGAL AIR COMPRESSOR

Air is drawn in at the turbine end of the compressor and passes through each stage successively, the pressure being gradually increased to that which the conditions in the furnace may require. The discharge pipe is at the far end of the compressor, as is shown in Fig. 2; it is insulated with wood-covered lagging. The pipe passes across the old blowing-engine house and out through the wall just above the lower windows, as shown in Fig. 1. It then drops down and connects into the header which in turn connects with the stoves. The compressor shell, as well as the

There are three bearings, one at the head end of the turbine, one between the turbine and the compressor and one at the discharge end of the compressor.

As in all high-speed apparatus, the continuity of the oil supply is important. The oil is circulated automatically by a valveless gear pump driven through a worm gear by the main shaft. The oil is pumped through the bearings at a pressure of from 15 to 25 pounds. The same pump supplies oil to the hydraulic cylinder, which operates the automatic steam-valve gear. The oil is returned

ute and develops 1740 brake horsepower, with a guaranteed steam consumption of 15.1 pounds per horsepower-hour. When delivering the same quantity of air against 25 pounds pressure, the speed of the compressor is 1975 revolutions per minute; the horsepower developed is 2600 and the guaranteed steam consumption is 14.6 pounds.

METHOD OF REGULATION

The manner in which the steam is regulated to deliver constantly a predetermined volume of air against any

pressure within the limits of the capacity of the machine is illustrated in Fig. 3. A counterweighted-steel disk is sustained by the current of inflowing air in the conical enlargement of the intake pipe. The rod to which the disk is attached passes through a stuffing box in the elbow of the intake and is connected to the weight beam *A* and to a system of levers which operates the pilot valve of the hydraulic valve gear, mounted over the head end of the turbine.

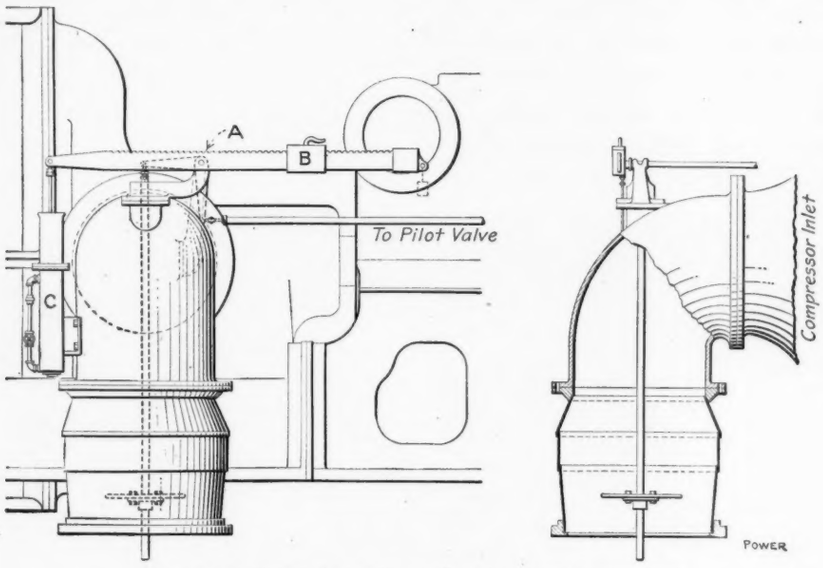


FIG. 3. SHOWING METHOD OF REGULATING COMPRESSOR

The notches on the beam are marked to correspond with various quantities of air delivered per minute. When the weight *B* is set at a given notch to deliver a certain quantity of air, the disk stands normally at a certain level in the intake cone. When the pressure against which the compressor is working increases for any reason the amount of air delivered begins to fall off. This reduces the velocity of the air being drawn through the intake cone and unbalances the disk, which consequently sinks to a lower level. The movement of the disk, acting through the system of levers, the pilot valve and the hydraulic valve gear, causes more steam to be admitted to the turbine. The turbine then speeds up and reëstablishes the proper rate of flow against the increased pressure.

This may be continued until the speed limit, 1975 revolutions per minute, is reached when a centrifugal governor comes into action and prevents any increase in the rate of steam admission. The dashpot *C*, Fig. 3, coupled to the weight beam, prevents undue fluctuation in speed and any tendency to race.

The turbine is fitted with an emergency governor which shuts down the machine when the speed for any reason exceeds by 10 per cent. the limit for which the speed governor is set.

The advantages of this type of compressor over the reciprocating types, either gas- or steam-driven, are, briefly: better over-all economy, economy in space occupied and more uniform operation. A rough idea of the saving in space occupied and the consequent saving in the cost of building effected by the use of a centrifugal compressor may be gained by observing the difference between the size of the old and that of the new engine house as shown in Fig. 1. The more uniform operation of the compressor results in an increase in the capacity of the furnace and an improvement in the quality of the product.

CONDENSER

The condenser is of the twin-barometric injector type and was designed by F. E. Johnson, of the M. W. Kellogg Company, New York. The location of the condenser is shown in Fig. 1 and its general arrangement in Fig. 4. The details of the heads are shown in Fig. 5.

The exhaust from the turbine passes out of the building below the turbine floor and enters the 36-inch cast-iron riser, Fig. 4. At the top of the riser the exhaust divides, one-half going to each condensing unit. The water belts of these units are connected by a 4-inch equalizing pipe, which eliminates all possibility of the units bucking each other on account of an unequal distribution of the exhaust steam or of the injection water.

The cast-iron elbow which connects

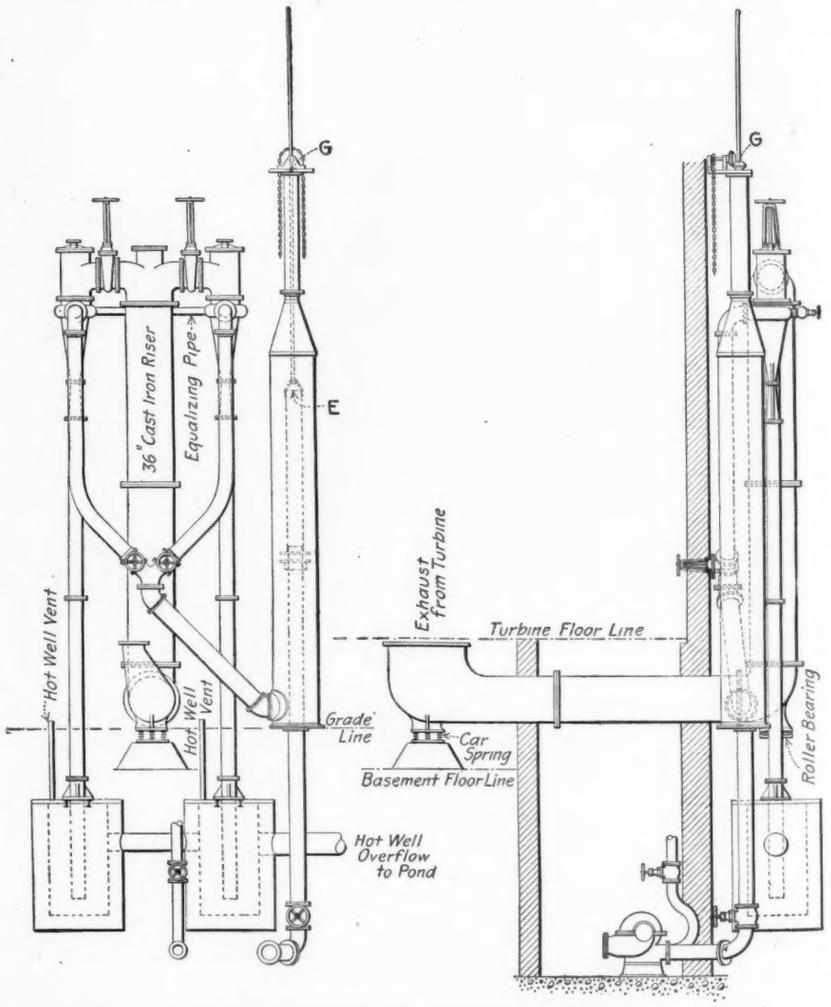


FIG. 4. GENERAL ARRANGEMENT OF CONDENSER

with the exhaust outlet of the turbine is supported on heavy car springs. By this simple arrangement the use of an expansion joint between the elbow and the exhaust outlet was avoided, and expansion joints are not the most satisfactory of things that have been devised. The base of the riser rests on a roller bearing so that provision is made for lateral as well as vertical expansion.

The condenser was sold under a guarantee that it would maintain a vacuum of 28 inches of mercury, referred to a 30-inch barometer, when condensing 30,000 pounds of steam per hour with injection water at 70 degrees and produce a hotwell temperature within 10 per cent. of that theoretically obtainable.

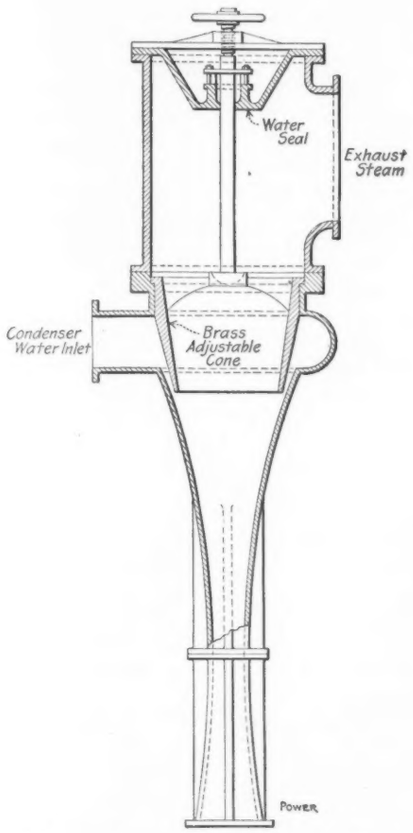


FIG. 5. DETAILS OF CONDENSER HEAD

The injection water leaves the pump through the 12-inch vertical pipe shown in Fig. 4 and spills over the edge of the open end *E* into the 30-inch steel-riveted standpipe from the base of which it is drawn to the condenser belt. In spilling out of the 21-inch pipe in a comparatively thin stream the water liberates a large proportion of the entrained air which escapes through the vent at *G*. Thus, the injection water goes through the condenser in an almost air-free condition and such air as is mingled with the exhaust steam is practically all that must be handled by the condenser.

PIPING AND PUMPS

The injection water is drawn from a pond 450 feet from the pump and 8 feet below the pump suction inlet. The suction line is 16 inches in diameter and made up of standard 20-foot lengths of pipe welded into 40-foot sections by the Kellogg system of electric welding, 40 feet being the limit of length convenient for transportation. Standard Van Stone joints are used between the sections. Due to this construction, which is unique in suction-pipe work, the line is absolutely air tight.

The injection water is handled by a 12-inch Morris Machine Works centrifugal pump, located as shown in Fig. 4, direct driven by a 100-horsepower noncondensing Terry turbine running at 1650 revolutions per minute. The pump has a capacity of 3300 gallons per minute against a normal static discharge head of 37 feet or a total normal static head of 45 feet.

The condenser-discharge water is received by the two hotwells shown in Fig. 4, from which it flows back to the pond by gravity. The hotwells are at a net hight of 15 feet above the pond. A natural-draft wooden cooling tower has been erected and will be put into service for the summer months. It stands at a level between that of the hotwells and that of the pond; hence, no pump will be required for the return of the discharge water even when the tower is in use.

In addition to the condenser pump, an 8-inch Morris Machine Works centrifugal pump is connected to the Terry turbine on the same shaft. This pump supplies 1200 gallons of water per minute to an elevated reservoir from which cooling water for the blast furnace and the air compressor is supplied by gravity. The total static head against which this pump works is 68 feet.

The amount of water which passes through the compressor jackets is just sufficient for the boiler feed. This water leaves the jackets at a temperature of about 100 degrees and enters a Cochrane open heater in which it is mingled with the exhaust steam from the Terry turbine. The temperature of the water as it enters the boilers is 180 to 200 degrees. The boiler feed pumps, two in number, are 12 and 8 by 12 inches in size and of the outside-packed duplex type. They were furnished by the Scranton Pump Company, Scranton, Penn.

Steam from the boilers enters a 12-inch header, 100 feet long, through welded nozzles carrying welded flanges. This construction eliminates about 70 per cent. of the joints ordinarily necessary.

CHIMNEY

The brick chimney which serves the blast-furnace stoves and the three Babcock & Wilcox boilers represents the latest chimney practice and is remarkable inasmuch as it is successfully withstanding, although only partially lined, temperatures which never fall below 800 degrees and sometimes run as high as 1400.

The hight of the chimney above its foundations is 175 feet, and the internal top diameter is 10 feet. The underground flue which connects the chimney with the stoves and boilers is built of concrete and lined with firebrick. The chimney wall is built in eleven sections. The bottom section is 10 feet high and 26

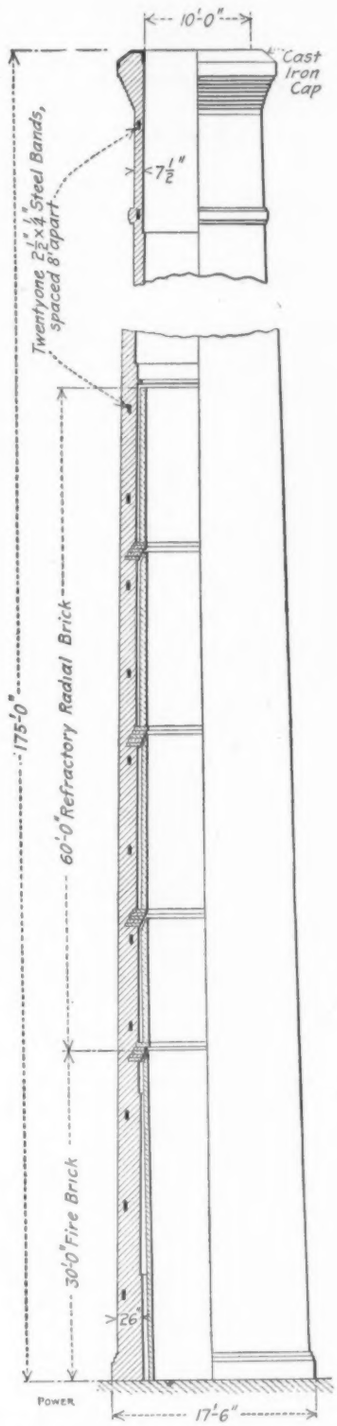


FIG. 6. DESIGN OF RADIAL BRICK CHIMNEY

inches thick; the ten sections above are each 16 feet 6 inches high, but vary in thickness from 24 inches, the thickness of the lowest one, to 7½ inches for the top one. The head of the chimney is finished with a sectional cast-iron cap which locks the top course of brick solidly in place and protects it from the action of the elements.

The chimney proper is built of perforated, corrugated radial brick laid in cement mortar. The lining is 90 feet high. The lower 30 feet is built of 4-inch firebrick laid in fire-clay mortar. The upper 60 feet is built in 15-foot sections of 4¼-inch hard-burned refractory radial brick. Each section is carried on a firebrick corbel and separated from the chimney wall by a 2-inch air space. The chimney wall is reinforced at 8-foot intervals by 2½x¼-inch steel bands. The M. W. Kellogg Company, New York, which erected the chimney, guarantees it to withstand a temperature of 1500 degrees Fahrenheit.

We acknowledge with appreciation the courtesy of R. H. Rice, of the General Electric Company, in supplying information concerning the centrifugal-air compressor and H. B. Cox, of the Empire Steel and Iron Company, in supplying the other information contained in this article.

The Confessions of an Engineer

By R. O. Warren

In this story the CO_2 recorder is up for discussion, and once more the manager finds that the engineer has failed to apply his knowledge and has missed an opportunity of making good by neglecting to suggest the purchase of a CO_2 recorder.

Manager Wood was about as progressive a man as one would meet in a long time. If I could have absorbed some of his push and hustle I might have occupied a pretty "hefty position" today, and incidentally been better off in dollars and cents.

One day Wood strolled into the boiler room where I was at the time, and, after his usual greeting, said. "What do you know in favor of CO_2 recorders?"

"They are a mighty good thing," said I. "Every boiler plant of any size should have one. A CO_2 recorder shows just what is going on in the boiler furnace, and tells just what percentage of CO_2 gas passes up the stack. Are you thinking of getting a recorder?"

"Not just yet. I never go into a thing before I have a pretty good idea of its value, what it does, how it works and of what use it can be to me. I'll confess I'm a little lame on the finer points of furnace combustion.

"I do know," went on Wood, "that the heat produced in a furnace depends on the completeness of combustion and on nothing else, and that the quantity of heat transferred to a boiler is determined by the state of the escaping gas."

"Yes, that's right," I replied, "and the escaping gas can be burned either to CO or to CO_2, according to the amount of air admitted to the furnace. The difference between the heat values of these two gases would surprise most engineers."

"What is the difference?" asked Wood.

"Well, burn a pound of carbon to CO_2, or carbon-dioxide, and it will yield 14,540 British thermal units. If the same carbon were burned to CO, or carbon-monoxide, it would yield but 4350 British thermal units—a difference of 10,190 heat units."

"Well, what makes the difference? A good deal must be in the method of firing, don't you think?"

"Sure, that has a whole lot to do with it," I replied, answering the last question first. "The reason that CO is formed is because not enough air has been admitted to the furnace. Of course, a furnace has got to be in decent shape, or the best firemen that ever lived can't fire and get good results."

"Most engineers don't really understand what burning flue gases to CO_2 means, but good combustion is simply burning coal to get the best results with the least possible air supply."

You see I was right at home on the CO_2 question, because I had read a good deal on the subject, knew all about the various apparatus on the market; and had a pretty good idea as to just the advantage of a CO_2 recorder. I knew that in the complete combustion of pure carbon there would be 20.7 per cent. by volume of CO_2, which fact I told the manager.

"But," said he, "you don't mean that you can get that amount of CO_2 from the fuel burned in a furnace, do you?"

"I should say not," I answered. "The best that can be got with the regular furnace is about 15 per cent. of CO_2 and that only for short periods. An average of 12 per cent. would be considered good for most plants."

"What saving would that make over, say 3 per cent. of CO_2?" was the next question.

"Well," I replied, feeling considerably gratified that we were considering a matter with which I was tolerably well familiar. "With 3 per cent. CO_2 the loss in coal is about 60 per cent., while with 12 per cent. CO_2 obtained, the loss in fuel is but 15 per cent."

"Whew—quite a difference. That's worth looking into."

"You bet," said I. "Every engineer should know about such things, for he don't know when he will have a chance to use the information."

Wood looked at me in rather an amused-surprised manner, and I, not knowing what was passing in his mind, went on with my explanation.

"The only way that a high percentage of CO_2 can be obtained is by firing at frequent intervals, by maintaining the proper thickness of fuel bed, and by supplying the correct amount of air for the fuel used. This can't be done if a furnace setting is full of cracks through which air can leak. If air leaks into the furnace it simply means that the furnace gases have to heat the excess air before it escapes to the stack, and much of the heat absorbed by the useless excess air is lost."

"There is usually excess air entering into a furnace, I take it."

"Yes, probably about 40 per cent. above the amount theoretically required," I replied. "This excess air dilutes the gases and reduces the percentage of CO_2 in the total volume of gases going up the stack. Under such a condition about 14 per cent. of CO_2 will be shown upon analysis, and the more air admitted to the furnace the lower the percentage of CO_2 and the greater the loss of fuel."

"And you say that this excess air is generally due to imperfect firing, and leaky settings?"

"Sure," I replied. "About nine out of every ten cases are due to these two causes, and it will be found that the flue gases contain only about 5 to 7 per cent. of CO_2, when they should contain at least 10 or 12 per cent.; and this means a loss of about 25 per cent. in coal."

"Then this 25 per cent. loss is a preventable loss. isn't it?" asked Wood.

"That's about the size of it," I replied. "The fact of the whole matter is that the furnace don't want too much or too little air, but just the right amount, for the varying condition of the fire."

"The idea," said I, "is that if the furnace conditions are so bad that the gases and air don't thoroughly mix, or if the temperature of the furnace is so low that the gases won't ignite, or if the boiler plates are cold enough to cool the gases and flame before complete combustion takes place, then CO is present in large

quantities and the CO_2 percentage is low.

"About the air," I went on. "If there is too much, then the fire is obliged to heat it before it goes up the stack, and no engineer tries to see how high he can get his chimney gases, or how low he can keep the temperature of a boiler furnace. The whole proposition hinges on the way a fireman handles his fires, providing, of course, that the furnace and grate, etc., are in good condition."

"I suppose then, so long as air plays such an important part, that the draft in the stack must be reckoned with?" said Wood, in a thoughtful tone.

"It certainly must," I replied. "A strong draft eats up coal, and no more draft should be allowed drawing on a boiler furnace than is absolutely necessary to produce a fire of such intensity as to supply the necessary steam to carry the load on the boiler. But the only way to know when the proper draft has been obtained is by knowing what percentage of CO_2 is being obtained."

"And that is by means of a CO_2 recorder of some make," said Wood, in a very positive tone. "Why don't more engineers have these recorders?" According to what you have told me, more steam can be raised with the same amount of coal if a CO_2 recorder is used than without the recorder. Or, in other words, the same amount of steam we are now using can be made with a less amount of coal if a recorder were used. If that is the case, it would not take very long for a recording instrument to pay for itself."

"I guess that is about right," I replied, dimly gathering an idea as to the point Wood was leading up to.

"A good CO_2 recorder would act in three capacities at once," went on Wood. "It would be a simple guide for the fireman and an effective check for the engineer."

"Yes, there's no doubt about that," I answered.

Wood mused for a moment and then said. "It seems strange that so many companies will spend thousands of dollars in building a modern steam plant, pay particular attention to pipe-line design, protect the steam pipes from atmospheric influences, install the best types of boiler and engine, and, in fact, take practically every known precaution against steam losses, and then pay no attention to the loss due to escaping combustible gases."

"It is a little strange," said I, while a slight shiver ran up and down my spine, for I began to see that in not getting after this matter of flue gases I had allowed a good opportunity to slip by unnoticed until the new manager had taken it up.

"The personal element in the boiler room is, in most cases, overlooked as either unimportant or not existing. I think that is what is done here, isn't it?" asked Wood.

"We have a good set of firemen," I answered. "They are careful and ———." Then I came to a halt, for it flashed through my mind that but a few days before the manager had seen a fireman standing lighting his pipe while the furnace doors were open.

Wood evidently recalled the same conversation for he smiled a little and said, "You are not quite sure as to their merits now, are you?"

"Of course, they are men, but when compared with other firemen they are above the average," I protested.

"Yes, they are men, and for that reason they need some means of guidance and control if proper combustion is to be obtained. And that guidance is the CO_2 recorder, because if they are to get the proper CO_2 percentage the proper draft must be maintained and the firing properly performed. A fireman will do his work better if he knows it is being checked. Isn't that so?"

I had to admit that it was.

Then Wood got right down to business and said, "You are a strange proposition, Warren. You know about things, but don't make good."

"How so," I asked, although I well knew what was coming.

"How so! Why you have known all about the losses due to imperfect combustion even since you have been here, but the only thing I can discover you have done to prevent them is that you have stopped up the cracks in the boiler settings."

"Well, that made quite a difference." I protested.

"Some, but not enough," retorted Wood. "You have told me enough about CO_2 recorders to satisfy me that you knew the full value of such apparatus, but you have never intimated that it would be advisable to have one in our steam plant."

"I know I never have, because they cost so much. I would have been wasting my breath, if I had proposed such a thing," I answered.

"How do you know you would?" demanded Wood. "While most business men don't care to spend money foolishly, there are but few who will not spend three or four hundred dollars if they are reasonably sure of getting the amount back in a reasonable time, because of the saving the expenditure will make.

"And another thing worth remembering. No business man will refuse to at least listen to any sane proposition. From what you have told me, together with the argument of the salesman, I think a CO_2 recorder will be a money saver in this plant."

I Had Another Interesting Session with the Manager

Here was another chance gone for making good. Although I knew all along of the advantage of a CO_2 recorder and about what saving one would make in a plant the size of mine, I had made no use of my knowledge, but had waited for the new manager to introduce a recording instrument, and, of course, the saving made would be to his credit.

Although I profited by this experience in after years, the occurrence made but little impression then, for in a few days after the new CO_2 recorder had got to be an old story. I forgot that I had missed one of the greatest opportunities of my life for making good by not applying what I knew to my everyday work.

Aid to Plotting Compression Curves

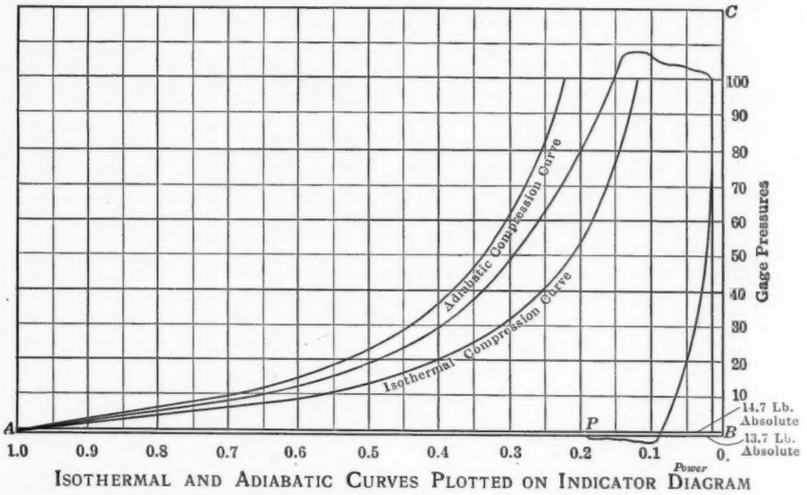
By H. V. Conrad

Tables providing data for conveniently laying out the theoretical isothermal and adiabatic curves on an indicator diagram taken from an air-compressor cylinder.

Indicator diagrams taken from air cylinders always show the compression curve as starting below the atmospheric line, when the compressor is drawing free air. This starting point of compression may range from ¼ pound, in the high-class machine, to 1½ pounds or more, below the atmospheric pressure, in machines having more or less restricted inlet passages.

Tables 1 and 2, provide data for quickly laying out in tenths of a pound the theoretical isothermal and adiabatic curves on indicator diagrams which start their compression anywhere between 14.7 and 10 pounds absolute. To prepare the indicator diagram for applying the tables, (see sketch) draw horizontal pressure lines at 10-pound intervals, to the scale of the indicator spring, using the portion *A P* of the diagram as a base line. Next, increase the length of the diagram by an amount equivalent to the percentage of the volumetric clearance in the cylinder at the end of the stroke, and erect the perpendicular line *B C*. Consider the length *A B* as one and divide it into 10 equal divisions. The tables give the horizontal measurements in percentages of one measured from the line *B C;* these locating the points of the compression curves on the various pressure lines.

As an example, the sketch shows a normal indicator diagram from an air cylinder compressing to 100 pounds, the volumetric end clearance being 1½ per cent., with compression starting at 1 pound below atmosphere at sea level; that is, at 13.7 pounds absolute. The diagram having been ruled with pressure lines and the subdivisions in length marked off, refer to isothermal values in Table 1 for 13.7 pounds absolute initial pressure. In the pressure columns will be found the horizontal measurements to be made on *A B*,



ISOTHERMAL AND ADIABATIC CURVES PLOTTED ON INDICATOR DIAGRAM

TABLE 1. ISOTHERMAL COMPRESSION LINE TABLE.

Absolute Initial Pressure, Pounds.	Gage Pressures in Pounds.															
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	130	150
14.7	0.855	0.746	0.595	0.424	0.329	0.269	0.227	0.197	0.174	0.155	0.140	0.128	0.118	0.1016	0.0894
14.6	0.854	0.745	0.593 +	0.422	0.327	0.2675	0.226	0.196	0.1728	0.1542	0.1393	0.1273	0.1172	0.101	0.0888
14.5	0.852 +	0.743 +	0.592 +	0.420	0.326	0.266	0.225	0.195	0.1716	0.1535	0.1386	0.1265	0.1165	0.1002	0.0882
14.4	0.852	0.743	0.591	0.418	0.3245	0.2648	0.224	0.1937	0.1706	0.1525	0.1380	0.1258	0.1157	0.0996	0.0876
14.3	0.852 —	0.742	0.589	0.417	0.323	0.2635	0.2225	0.1925	0.1696	0.1516	0.1372	0.1250	0.1150	0.0991	0.0870
14.2	0.851	0.741	0.587	0.416	0.3215	0.2622	0.221	0.1915	0.1686	0.1508	0.1364	0.1242	0.1143	0.0986	0.0864
14.1	0.850	0.740	0.585	0.414	0.320	0.261	0.220	0.1905	0.1676	0.1500	0.1356	0.1235	0.1137	0.0979	0.0859
14.0	0.849	0.738	0.583	0.412	0.3185	0.2595	0.219	0.1895	0.1666	0.1491	0.1347	0.1228	0.1130	0.0972	0.0853
13.9	0.848	0.736	0.582	0.411	0.3165	0.2578	0.2175	0.1884	0.1657	0.1482	0.1338	0.1220	0.1123	0.0966	0.0848
13.8	0.847	0.734	0.580	0.409	0.3150	0.2563	0.2165	0.1873	0.1648	0.1472	0.1330	0.1212	0.1116	0.0960	0.0842
13.7	0.846	0.733	0.578	0.407	0.3135	0.2550	0.2152	0.1862	0.1638	0.1462	0.1322	0.1205	0.1109	0.0953	0.0837
13.6	0.845	0.732	0.577	0.405	0.3120	0.2537	0.2140	0.1850	0.1627	0.1453	0.1313	0.1197	0.1101	0.0947	0.0831
13.5	0.844	0.730	0.575	0.403	0.3105	0.2522	0.2125	0.1838	0.1616	0.1444	0.1305	0.1189	0.1093	0.0940	0.0825
13.4	0.843	0.728	0.573	0.402	0.309	0.2510	0.2112	0.1826	0.1606	0.1435	0.1296	0.1181	0.1085	0.0934	0.0820
13.3	0.842	0.726	0.571	0.400	0.307	0.2495	0.2100	0.1814	0.1596	0.1426	0.1286	0.1173	0.1078	0.0928	0.0814
13.2	0.841	0.725	0.569	0.398	0.305	0.248	0.2090	0.1803	0.1586	0.1418	0.1278	0.1166	0.1071	0.0922	0.0809
13.1	0.840	0.724	0.568	0.396	0.304	0.2465	0.2076	0.1792	0.1575	0.1408	0.1270	0.1158	0.1063	0.0916	0.0804
13.0	0.839	0.723	0.566	0.394	0.302	0.2452	0.2062	0.1780	0.1565	0.1398	0.1263	0.1151	0.1057	0.0910	0.0798
12.9	0.838	0.721	0.564	0.3923	0.301	0.2437	0.205	0.1770	0.1556	0.1389	0.1254	0.1142	0.1050	0.0903	0.0792
12.8	0.837	0.719	0.562	0.3908	0.2992	0.2424	0.2035	0.1758	0.1546	0.1379	0.1245	0.1136	0.1043	0.0896	0.0786
12.7	0.836	0.7175	0.560	0.3892	0.2975	0.2410	0.2023	0.1747	0.1536	0.1370	0.1238	0.1128	0.1036	0.0890	0.0781
12.6	0.835	0.716	0.558	0.3875	0.2960	0.2395	0.2012	0.1735	0.1526	0.1361	0.1229	0.1119	0.1028	0.0884	0.0775
12.5	0.834	0.714	0.556	0.3850	0.2942	0.2380	0.2000	0.1725	0.1516	0.1352	0.1220	0.1111	0.1021	0.0877	0.0769
12.4	0.832	0.713	0.554	0.3827	0.2925	0.2368	0.1987	0.1712	0.1505	0.1341	0.121	0.1102	0.1012	0.0871	0.0764
12.3	0.831	0.712	0.552	0.381	0.291	0.2355	0.1974	0.1701	0.1495	0.1331	0.120	0.1094	0.1005	0.0865	0.0758
12.2	0.830	0.71 —	0.550	0.379	0.289	0.2338	0.1961	0.169	0.1485	0.1322	0.1192	0.1086	0.0998	0.0858	0.0752
12.1	0.829	0.709	0.548	0.377	0.2872	0.2321	0.1948	0.1679	0.1474	0.1314	0.1185	0.1078	0.0992	0.0852	0.0747
12.0	0.828	0.707	0.546	0.3755	0.2857	0.2306	0.1936	0.1667	0.1463	0.1306	0.1177	0.1070	0.0985	0.0847	0.0741
11.9	0.827	0.705	0.544	0.3735	0.2842	0.2292	0.1925	0.1656	0.1452	0.1295	0.1168	0.1063	0.0977	0.0840	0.0736
11.8	0.826	0.703	0.542	0.3715	0.2821	0.2278	0.1910	0.1644	0.1441	0.1285	0.1159	0.1055	0.0970	0.0833	0.0730
11.7	0.8245	0.701	0.540	0.3692	0.2805	0.2262	0.1895	0.1632	0.1431	0.1276	0.115	0.0048	0.0963	0.0826	0.0725
11.6	0.823	0.699	0.538	0.367	0.279	0.225	0.1884	0.162	0.142	0.1266	0.1142	0.104	0.0956	0.082	0.0719
11.5	0.8215	0.697	0.536	0.365	0.277	0.2235	0.1872	0.1609	0.141	0.1258	0.1133	0.1032	0.0947	0.0813	0.0713
11.4	0.820	0.695	0.532	0.363	0.2755	0.222	0.186	0.1598	0.140	0.1249	0.1124	0.1024	0.0939	0.0807	0.0707
11.3	0.8185	0.693	0.530 +	0.361	0.2738	0.2205	0.1845	0.1585	0.139	0.1239	0.1116	0.1015	0.0932	0.080	0.0701
11.2	0.817	0.6915	0.529 —	0.359	0.272	0.219	0.183	0.1574	0.138	0.1229	0.1108	0.1007	0.0925	0.0794	0.0695
11.1	0.8157	0.690	0.527	0.357	0.2704	0.2175	0.1818	0.1564	0.137	0.1219	0.1099	0.0999	0.0917	0.0787	0.0689
11.0	0.8143	0.688	0.5245	0.355	0.2685	0.216	0.1805	0.155	0.136	0.121	0.1090	0.0992	0.091	0.0781	0.0684
10.9	0.8136	0.686	0.522	0.353	0.2665	0.2142	0.179	0.1539	0.1348	0.120	0.1080	0.0984	0.0902	0.0774	0.0678
10.8	0.813	0.684	0.520	0.351	0.2645	0.213	0.1775	0.1525	0.1335	0.119	0.107	0.0976	0.0895	0.0768	0.0672
10.7	0.812	0.682	0.518	0.349	0.263	0.211	0.176	0.1513	0.1325	0.118	0.1061	0.0968	0.0887	0.0761	0.0666
10.6	0.810 +	0.680	0.515	0.346 +	0.261	0.209	0.175 —	0.150	0.1315	0.117	0.1053	0.096	0.088	0.0755	0.0661
10.5	0.808 +	0.678	0.512	0.344	0.259	0.208	0.1735	0.149	0.1305	0.116	0.1044	0.0951	0.0872	0.0748	0.0655
10.4	0.807	0.676	0.510	0.342	0.257 +	0.2065	0.172	0.148	0.1295	0.115	0.1035	0.0943	0.0864	0.0741	0.0649
10.3	0.805	0.674	0.508	0.340	0.256 —	0.205	0.1705	0.1465	0.1283	0.114	0.1026	0.0935	0.0857	0.0735	0.0643
10.2	0.804	0.672	0.506	0.338 —	0.254	0.203	0.1695	0.145 +	0.1272	0.113	0.1017	0.0926	0.0849	0.0728	0.0638
10.1	0.802	0.669	0.503	0.335	0.252	0.202	0.168 +	0.144	0.1261	0.112	0.1008	0.0918	0.0841	0.0721	0.0632
10.0	0.80	0.666	0.50	0.333	0.25	0.20	0.1666	0.143	0.125	0.111	0.10	0.091	0.0834	0.0715	0.0625

TABLE 2. ADIABATIC COMPRESSION LINE TABLE.

Absolute Initial Pressure, Pounds.	Gage Pressures in Pounds.														
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	130	150
14.7	0.895	0.812	0.692	0.543	0.454	0.393	0.349	0.315	0.288	0.266	0.248	0.233	0.2192	0.1973	0.180
14.6	0.895 −	0.811 +	0.691	0.542	0.453	0.392	0.348	0.314	0.287 +	0.265	0.247	0.232	0.2181	0.1961	0.179
14.5	0.894 +	0.811	0.690	0.541	0.452	0.391	0.347	0.313	0.287 −	0.264	0.246 +	0.231 +	0.217	0.195	0.178
14.4	0.894	0.810	0.688	0.539	0.450	0.389 +	0.345 +	0.312 −	0.285	0.263 +	0.245	0.229 +	0.216	0.194 +	0.177
14.3	0.893	0.809	0.686	0.538	0.448	0.388	0.344	0.310 +	0.284	0.262	0.244	0.228 +	0.215 +	0.193 +	0.176 +
14.2	0.892	0.808	0.685	0.537	0.447	0.387 −	0.342 +	0.309	0.283 −	0.261 −	0.243	0.227 +	0.214 +	0.193 −	0.176 −
14.1	0.891	0.807	0.683 +	0.535	0.445	0.385 +	0.341 +	0.308	0.281 +	0.260	0.242	0.226 +	0.213 +	0.192	0.175 +
14.0	0.890	0.806	0.682	0.533	0.444 −	0.384 −	0.340	0.307	0.280 +	0.259	0.241	0.226 −	0.212 +	0.191 +	0.175 −
13.9	0.889	0.805 −	0.681	0.532	0.442	0.382 +	0.338	0.305	0.279 +	0.258 −	0.240	0.225	0.211 +	0.190 +	0.173 +
13.8	0.889 −	0.803	0.680 −	0.530	0.441	0.381 −	0.337	0.304	0.278	0.257 −	0.239	0.224 −	0.211 −	0.189 +	0.172 +
13.7	0.888	0.802 +	0.678	0.528	0.439 +	0.379 +	0.336	0.303 +	0.276 +	0.255 +	0.238	0.222 +	0.210 −	0.188 +	0.171 +
13.6	0.888 −	0.801	0.677	0.527	0.437 +	0.378 −	0.334 +	0.302 −	0.275 +	0.254	0.237 −	0.221 +	0.209 −	0.187 +	0.171 −
13.5	0.887	0.800 −	0.676 −	0.525	0.436	0.376 +	0.333 +	0.300 +	0.274 +	0.253 −	0.235 +	0.221 −	0.208 −	0.187 −	0.170
13.4	0.887 −	0.779	0.674	0.523 +	0.434	0.375	0.332 −	0.299	0.273 +	0.251 +	0.234 +	0.220 −	0.207 −	0.186	0.169 +
13.3	0.885 +	0.798 −	0.672	0.522	0.433	0.373 +	0.330	0.298 −	0.272	0.250 +	0.233	0.219 −	0.206 −	0.185 −	0.168 +
13.2	0.884	0.796 +	0.671	0.520 +	0.431 +	0.371 +	0.329	0.296 +	0.270 +	0.249 +	0.232	0.217 +	0.204 +	0.184 −	0.168 −
13.1	0.884 −	0.795	0.670 −	0.518	0.429	0.369	0.328	0.295	0.269	0.248 +	0.231	0.216 +	0.203 +	0.183	0.167 +
13.0	0.883 −	0.794	0.667 +	0.516	0.428 −	0.368	0.327	0.293 +	0.268	0.248 −	0.230	0.215 +	0.202 +	0.182	0.166 +
12.9	0.882	0.793	0.665 +	0.515 −	0.426 +	0.367 +	0.325	0.292 +	0.267	0.246 +	0.228 +	0.214	0.202 −	0.181	0.165
12.8	0.881 +	0.792	0.664	0.513	0.425 −	0.366	0.323	0.291	0.266 −	0.245	0.227 +	0.213	0.201	0.180 +	0.164 +
12.7	0.880 +	0.791	0.662 +	0.512 −	0.423	0.364	0.322 −	0.290 −	0.264	0.244	0.226 +	0.212	0.200	0.180 −	0.163 +
12.6	0.880	0.790 −	0.661	0.510	0.421 +	0.362 +	0.320 +	0.288 +	0.263	0.243 −	0.225 +	0.211	0.199	0.179 −	0.163 −
12.5	0.880 −	0.788	0.660 −	0.508	0.420	0.361	0.319	0.287	0.262	0.241 +	0.224 +	0.210	0.198	0.178 −	0.162 −
12.4	0.878 +	0.787 −	0.658	0.506	0.418	0.360 −	0.318	0.286	0.2605	0.240	0.2235	0.209	0.1967	0.177 −	0.161
12.3	0.877	0.785 +	0.656	0.504	0.416	0.358	0.317	0.2845	0.259	0.239	0.222	0.208	0.1955	0.176	0.160
12.2	0.876	0.784	0.654	0.502	0.414 +	0.3556	0.315	0.283	0.258 −	0.238	0.221	0.207 −	0.1945	0.175	0.159
12.1	0.8755	0.783	0.652 +	0.500	0.413 −	0.354	0.313 +	0.281 +	0.2565	0.237	0.220	0.2055	0.1938	0.174	0.1582
12.0	0.875	0.782	0.651	0.498	0.411	0.353	0.312 −	0.280	0.255 +	0.236	0.219	0.2046	0.1930	0.173	0.1575
11.9	0.874	0.780 +	0.649	0.496	0.409	0.351 +	0.310	0.279	0.254	0.234 +	0.218	0.2038	0.1920	0.172	0.1567
11.8	0.873	0.779 −	0.647	0.4945	0.407	0.350	0.309 −	0.278 −	0.2527	0.233	0.2167	0.2029	0.1910	0.1712	0.1559
11.7	0.872	0.777	0.646 −	0.493	0.405	0.348 +	0.307	0.2765	0.2515	0.232 −	0.2155	0.2019	0.1900	0.1703	0.1551
11.6	0.871	0.776 −	0.644	0.491	0.4035	0.346 +	0.3055	0.275	0.2503	0.2307	0.2144	0.2008	0.1888	0.1695	0.1543
11.5	0.870 −	0.774	0.642	0.489	0.402	0.345	0.3041	0.2736	0.2489	0.2293	0.2132	0.1995	0.1876	0.1685	0.1534
11.4	0.869 −	0.772 +	0.640	0.487 +	0.400	0.344 −	0.3028	0.2721	0.2475	0.228	0.2119	0.1983	0.1865	0.1675	0.1525
11.3	0.867 +	0.771	0.638	0.486 −	0.398 +	0.342	0.3014	0.2707	0.2462	0.2268	0.2107	0.1972	0.1855	0.1667	0.1515
11.2	0.866	0.770 −	0.636	0.484	0.397 −	0.340 +	0.2998	0.2692	0.2450	0.2256	0.2096	0.1961	0.1845	0.1656	0.1506
11.1	0.865	0.768	0.634	0.482	0.395	0.339 −	0.2982	0.2678	0.2439	0.2245	0.2084	0.1949	0.1834	0.1645	0.1497
11.0	0.864	0.767	0.632	0.480	0.393	0.337	0.2966	0.2663	0.2428	0.2233	0.2072	0.1937	0.1824	0.1634	0.1488
10.9	0.863	0.766	0.630	0.478	0.391	0.335	0.295	0.265	0.2412	0.2218	0.2061	0.1926	0.1812	0.1624	0.1479
10.8	0.862 +	0.7645	0.628	0.476	0.389	0.333	0.2935	0.2635	0.2395	0.221	0.205	0.1916	0.180	0.1614	0.147
10.7	0.862 −	0.763	0.626	0.474 −	0.387	0.3315	0.292 −	0.262	0.238	0.219 +	0.204 −	0.1905	0.179	0.1605	0.1462
10.6	0.861	0.761	0.624	0.471	0.385 +	0.330 −	0.290	0.2605	0.237 −	0.218 −	0.2025	0.1895	0.178	0.1595	0.1455
10.5	0.860	0.759	0.622	0.469	0.384	0.328	0.288 +	0.259	0.2355	0.217 −	0.2012	0.188	0.177 −	0.1585	0.1446
10.4	0.858 +	0.757 +	0.620	0.467	0.382	0.326	0.287	0.258 −	0.234 −	0.2155	0.200	0.187 −	0.176 −	0.1575	0.1435
10.3	0.857	0.756 −	0.618	0.465	0.380	0.324 +	0.285	0.256	0.233 −	0.214	0.199 −	0.186 −	0.1745	0.1565	0.1427
10.2	0.856	0.754	0.616	0.463	0.378	0.323	0.2835	0.254	0.2317	0.213	0.1977	0.1846	0.1735	0.1555	0.1418
10.1	0.855	0.752	0.614	0.461	0.376	0.321	0.282	0.253 −	0.230	0.2115	0.1965	0.1835	0.172 +	0.1546	0.1407
10.0	0.853 +	0.750	0.612	0.459	0.374	0.319	0.280 +	0.251 +	0.2285	0.210 +	0.195	0.1825	0.171 +	0.1537	0.1396

TABLE 3. NUMBER OF ATMOSPHERES OR COMPRESSIONS.

Absolute Initial Pressure, Pounds.	Gage Pressures in Pounds.														
	2.5	5	10	20	30	40	50	60	70	80	90	100	110	130	150
14.7	1.170	1.340	1.680	2.360	3.040	3.721	4.401	5.080	5.762	6.442	7.122	7.803	8.483	9.843	11.204
14.6	1.171	1.342	1.685	2.370	3.054	3.739	4.424	5.109	5.794	6.479	7.164	7.849	8.534	9.904	11.274
14.5	1.173	1.344	1.690	2.380	3.069	3.758	4.448	5.138	5.827	6.517	7.207	7.896	8.586	9.965	11.345
14.4	1.174	1.347	1.695	2.390	3.083	3.777	4.472	5.166	5.861	6.555	7.250	7.944	8.649	10.028	11.416
14.3	1.175	1.350	1.700	2.399	3.098	3.797	4.496	5.196	5.895	6.594	7.294	7.993	8.692	10.091	11.490
14.2	1.176	1.353	1.705	2.408	3.112	3.817	4.521	5.225	5.930	6.634	7.333	8.042	8.746	10.155	11.563
14.1	1.177	1.355	1.709	2.418	3.127	3.837	4.546	5.255	5.965	6.674	7.383	8.092	8.801	10.220	11.638
14.0	1.178	1.357	1.714	2.428	3.142	3.857	4.571	5.285	6.000	6.715	7.429	8.143	8.857	10.290	11.714
13.9	1.180	1.360	1.719	2.438	3.158	3.877	4.597	5.316	6.036	6.755	7.475	8.194	8.913	10.352	11.791
13.8	1.181	1.363	1.724	2.449	3.174	3.898	4.623	5.348	6.072	6.797	7.522	8.246	8.971	10.420	11.869
13.7	1.182	1.365	1.729	2.460	3.190	3.919	4.649	5.379	6.109	6.839	7.570	8.300	9.029	10.489	11.949
13.6	1.183	1.367	1.735	2.470	3.206	3.941	4.676	5.411	6.147	6.882	7.618	8.353	9.088	10.559	12.030
13.5	1.185	1.370	1.740	2.481	3.222	3.963	4.703	5.444	6.185	6.926	7.666	8.408	9.148	10.630	12.111
13.4	1.186	1.373	1.746	2.492	3.238	3.985	4.731	5.477	6.224	6.970	7.716	8.463	9.209	10.701	12.194
13.3	1.188	1.376	1.752	2.503	3.255	4.007	4.759	5.511	6.263	7.015	7.767	8.519	9.270	10.774	12.250
13.2	1.190	1.379	1.758	2.515	3.272	4.030	4.788	5.545	6.303	7.060	7.818	8.576	9.333	10.848	12.463
13.1	1.191	1.381	1.764	2.526	3.290	4.053	4.817	5.580	6.343	7.106	7.870	8.634	9.397	10.924	12.450
13.0	1.192	1.384	1.770	2.538	3.308	4.077	4.846	5.615	6.384	7.153	7.923	8.692	9.460	11.000	12.538
12.9	1.194	1.387	1.775	2.550	3.325	4.100	4.876	5.651	6.426	7.201	7.976	8.752	9.529	11.077	12.627
12.8	1.196	1.390	1.781	2.562	3.343	4.125	4.906	5.687	6.468	7.250	8.031	8.813	9.593	11.156	12.719
12.7	1.197	1.393	1.787	2.574	3.362	4.149	4.937	5.724	6.512	7.299	8.086	8.874	9.661	11.236	12.811
12.6	1.198	1.397	1.794	2.587	3.381	4.174	4.968	5.762	6.555	7.349	8.142	8.937	9.730	11.317	12.905
12.5	1.200	1.400	1.800	2.600	3.400	4.400	5.000	5.800	6.600	7.400	8.200	9.000	9.800	11.400	13.000
12.4	1.202	1.403	1.806	2.613	3.420	4.226	5.033	5.839	6.645	7.451	8.258	9.064	9.871	11.484	13.097
12.3	1.203	1.406	1.813	2.627	3.440	4.254	5.067	5.878	6.691	7.504	8.317	9.130	9.943	11.570	13.195
12.2	1.204	1.410	1.820	2.640	3.460	4.280	5.100	5.918	6.737	7.557	8.377	9.197	10.016	11.655	13.295
12.1	1.206	1.413	1.826	2.653	3.480	4.305	5.133	5.959	6.785	7.611	8.438	9.264	10.090	11.744	13.397
12.0	1.208	1.416	1.833	2.665	3.500	4.333	5.166	6.000	6.833	7.666	8.500	9.333	10.166	11.833	13.500
11.9	1.210	1.420	1.840	2.680	3.520	4.361	5.200	6.042	6.874	7.723	8.563	9.403	10.244	11.924	13.605
11.8	1.212	1.424	1.848	2.695	3.542	4.390	5.237	6.085	6.932	7.780	8.627	9.474	10.322	12.010	13.712
11.7	1.214	1.427	1.855	2.710	3.564	4.420	5.273	6.128	6.983	7.828	8.692	9.547	10.401	12.111	13.820
11.6	1.216	1.431	1.862	2.724	3.586	4.450	5.310	6.172	7.035	7.900	8.758	9 620	10.483	12.207	13.931
11.5	1.218	1.435	1.870	2.739	3.609	4.478	5.348	6.217	7.087	7.975	8.826	9.696	10.565	12.304	14.043
11.4	1.220	1.439	1.878	2.754	3.632	4.509	5.386	6.263	7.140	8.017	8.900	9.772	10.649	12.403	14.158
11.3	1.222	1.442	1.885	2.770	3.655	4.540	5.425	6.310	7.194	8.080	8.964	9.850	10.734	12.504	14.274
11.2	1.224	1.446	1.893	2.785	3.678	4.571	5.464	6.357	7.250	8.143	9.035	9.928	10.821	12.607	14.394
11.1	1.226	1.450	1.901	2.800	3.702	4.603	5.504	6.405	7.306	8.207	9.108	10.010	10.910	12.712	14.513
11.0	1.228	1.454	1.909	2.817	3.725	4.635	5.545	6.455	7.363	8.273	9.181	10.091	11.000	12.818	14.636
10.9	1.230	1.458	1.917	2.835	3.752	4.670	5.587	6.505	7.422	8.340	9.257	10.174	11.091	12.927	14.761
10.8	1.231	1.462	1.926	2.852	3.777	4.704	5.630	6.555	7.481	8.407	9.333	10.259	11.185	13.037	14.888
10.7	1.233	1.467	1.934	2.870	3.803	4.738	5.673	6.607	7.542	8.477	9.411	10.346	11.280	13.150	15.019
10.6	1.235	1.471	1.943	2.887	3.830	4.773	5.717	6.660	7.604	8.547	9.490	10.434	11.377	13.264	15.151
10.5	1.238	1.476	1.952	2.905	3.857	4.809	5.762	6.714	7.666	8.619	9.571	10.524	11.476	13.381	15.286
10.4	1.240	1.480	1.960	2.923	3.884	4.846	5.807	6.769	7.730	8.692	9.654	10.615	11.577	13.500	15.423
10.3	1.243	1.485	1.970	2.942	3.912	4.883	5.853	6.825	7.796	8.767	9.738	10.709	11.679	13.621	15.563
10.2	1.245	1.490	1.980	2.961	3.940	4.921	5.900	6.882	7.862	8.843	9.823	10.804	11.784	13.745	15.706
10.1	1.248	1.495	1.990	2.980	3.970	4.960	5.950	6.940	7.930	8.920	9.911	10.901	11.891	13.871	15.851
10.0	1.250	1.500	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.000	11.000	12.000	14.000	16.000

for the points in the compression curve—on the 20-pound line this is 0.407, on the 40-pound line 0.255, etc. The adiabatic values in Table 2 for 13.7 pounds absolute initial pressure give, on the 30-pound line 0.439, on the 50-pound line 0.336, etc. Thus a sufficient number of points are located to readily and accurately construct the curves.

The tables being worked down to 10 pounds absolute pressure, may be used up to 10,000 feet altitude, provided the inlet pressure does not start below 10 pounds.

The tables also show the approximate position (somewhere between the isothermal and adiabatic curves) of the piston, in percentage of its stroke, for any of the given pressures, and from the isothermal table may be seen the relative volume of air delivered at the given pressures as compared with the original volume, considered as 1, at initial pressure.

Table 3 shows the number of compressions that the initial absolute pressures undergo to reach the given gage pressures, and also represents the number of atmospheres (initial pressure atmospheric) in the given gage pressure.

Old Boilers Doomed by Modern Laws

By William Faulkner

These old vessels which had been moved from the land of the Michiganites to that of the Seattleites were condemned by the wise men of the latter place and a calamity thereby averted.

And it came to pass in the second year of the reign of President Harrison that various artisans, workers in iron and steel, gathered together in the land of the Michiganites and said: "Let us get some earth and turn it with fire and make iron so our craft may be known throughout the land, even from shore to shore." So they made iron and tested it and found it good and were well pleased. And behold, there came a captain of the craftsmen who were skilled workers in wood, and he said: "I am sore distressed because I cannot get sufficient horses to do my work."

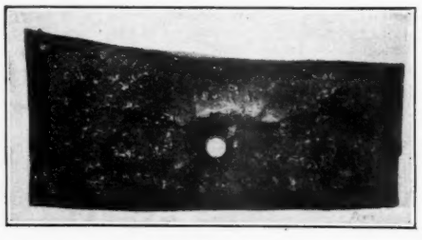
Then called he unto the captain of the workers in iron and steel and said unto him: "Make me a machine the same as James of the Wattites invented, and let it be equal to the strength of two hundred horses. And build me three vessels of iron in which water can be turned into steam."

So the captain of the workers in wood delivered unto the captain of the workers in iron and steel several bags of gold and said "Take this and deliver it to all your craftsmen who work diligently and when I return on the morrow I will pay thee in full." And there was great rejoicing in the land of the Michiganites. Then the captain of the workers in iron and steel sent for a scribe to draw a design for the three large vessels of iron, and he made a design for a vessel 192 inches in length, 60 inches in diameter and 3/8 of an inch in thickness, and he ordered that the sheets should be lapped and held together by two rows of rivets 13/16 of an inch in thickness, spaced 2¼ inches apart. The artisans then built three iron vessels according to the word of the scribe and they tested them with water and ordered that they should carry a working pressure of 100 pounds on every square inch.

Then came the captain of the workers in wood and looked upon the machine and the vessels of iron and he was well pleased.

Then came a great dearth of wood in the land of the Michiganites, so they sent messengers east and west and commanded them to find wood. And a messenger came from afar and he cried aloud and said, "Rejoice with me for I have found great amounts of wood in the land of the Seattleites."

And it came to pass that they journeyed to a far western country and dwelt among strange tribes that they might obtain wood with which to carry on their craft. So the captain of the workers in wood took with him all his machines and



CRACK IN BOILER SHEET

the three large vessels of iron and set them up in the land of the Seattleites, and they are there even unto this day.

In the second year of the reign of President Taft a number of wise men gathered together in the land of the Seattleites and said, "Behold, there are iron vessels in the country round about us which have been there since the days of our forefathers, and some have gone hence and the noise they made was like unto thunder and the people were much afraid."

So they appointed a number of skilled craftsmen to examine every vessel of iron and every vessel of steel and commanded them to test the vessels with water and with hammer and place their seal on all that were safe, and all that were unsafe they should condemn forever. And it came to pass that one appointed as examiner went to where the captain of the workers in wood had his iron vessels which he had brought from the land of the Michiganites in the year of President Harrison. And the examiner found a crack in one of the vessels of iron and he called unto him skilled workers and commanded them to cut out a piece of the iron vessel around about the crack, and when he measured the piece of iron it was found to be but 1/8 of an inch in thickness, so he condemned that vessel forever.

But the captain of the workers in wood was exceedingly wroth and he called the examiner before him and said unto him, "Would that I had the jaw bone of an ass that I might smite thee." And the examiner answered, "Knowest thou not that thou hast or thou wouldst not carry 100 pounds on each square inch of these old vessels and thereby endanger the lives of your craftsmen."

Then the captain of the workers in wood was much afraid and he shook with fear and said, "I must drink some wine; I pray thee come with me." And the wine softened his heart and he harkened to the words of the examiner and sent for laborers who rent the old vessels to pieces and modern vessels were placed in their stead.

Some weeks ago, just after starting up the 13x18-inch engine in the planing mill of the Central Mill and Lumber Company, of Colville, Wash., the 16-inch belt was thrown, catching in the automatic governor and completely demolishing it, also breaking the eccentric and bending the connecting bar. A two weeks' shutdown was the result. The cause of the accident was an open drip from the exhaust. The night watchman was used to "cracking" the throttle early so as to warm up the engine, and on this particular morning neglected to close the drip on which there was an ell pointing toward the belt. Not much steam went out of this ell, but what did condensed and fell on the belt and froze there, where it remained unnoticed in the darkness of the morning until the load from the mill was thrown on. At this moment the belt slipped and did the damage previously mentioned.

Proper Use of the Term "Efficiency"

By A. C. Wilson

Although, fundamentally, the term efficiency represents the ratio of the energy supplied to the work done, it needs qualification in each particular case in order to avoid confusion.

Generally speaking, the efficiency of a machine is the ratio between the energy supplied and the useful work done, the difference between these two quantities being a measure of the waste or the loss of work in the machine. If W is the number of foot-pounds of work per minute required to drive a hoist and w is the number of foot-pounds of work done during the same time in lifting a weight, the efficiency of the hoist is

$$w \div W$$

and the work wasted is

$$W - w.$$

The amount $W - w$ does not disappear but is expended in overcoming friction and, being converted into heat, is consequently not useful work as regards the purpose for which the hoist is intended. There are two ways of measuring efficiency; W and w may be measured directly or either one of them and $W - w$ may be measured. Circumstances usually decide which method is the more convenient. In the majority of cases it is not easy to measure the waste work directly as this appears in the form of heat at the different bearings and the efficiency must be determined by measuring W and w.

It might appear from the foregoing that the efficiency of an engine or other machine is an absolute quantity and requires no further description, but, as a matter of fact, the term is used with reference to any ratio which is a measure of the economical performance in some sense or another and without further qualification conveys little or no information. The efficiency is always a ratio between the actual performance of a machine and an ideal performance, and to use the term without so qualifying it as to convey exactly what ratio is meant is either misleading or useless. Many trade advertisements and catalogs are full of examples of a vague use of the term efficiency. By common usage a number of ratios relative to the performance of steam engines, boilers, dynamos, pumps, etc., are described by prefixing a qualifying term, such as the thermal efficiency of a boiler, or the mechanical efficiency of a steam engine; and if this prefix is used, the ratio is immediately known, but where there is no such understanding it is necessary to state what ratio is meant, if the figures are to convey any meaning at all.

In a steam boiler the efficiency which is ordinarily desired is the ratio between the heat imparted to the water and the total heat in the coal put onto the grate. This ratio is usually known as the thermal efficiency and appears to be a sufficiently simple and straightforward thing to determine. There are, however, several opportunities for ambiguity, even here. The heat imparted to the water is the number of pounds of water evaporated per pound of coal fired, multiplied by the increase in the total heat per pound from that contained in the feed water pumped into the boiler to that of the steam leaving it. If the steam is dry saturated, the latter quantity can be ascertained from steam tables if the boiler pressure is known, but if the steam is wet, the degree of wetness must be measured by a steam calorimeter and if the steam is superheated, its temperature must be known. The total heat imparted to a pound of wet steam at a given pressure is less than that in a pound of dry steam at that pressure by an amount equal to the latent heat of that fraction which is in the form of water; that is, if steam is found to be 2 per cent. wet and the absolute pressure is 100 pounds the total heat per pound is

$$1186.3 - (0.02 \times 888) = 1168.54 \ B.t.u.$$

measured from 32 degrees Fahrenheit. Similarly if steam is superheated in the boiler the total heat per pound is greater than the total heat of saturated steam at the same pressure by the specific heat of superheated steam multiplied by the difference in temperature between the superheated steam and that of saturated steam at the same boiler pressure, which latter may be found from steam tables.

The total heat in the coal is found by a laboratory test in a calorimeter and this may represent the heat in a sample after drying or in the same condition, as regards wetness, in which it was actually used. The amount of wetness in the coal as used is also determined in the laboratory. If the chemist states the heat value of dry coal it is evident that an additional calculation will have to be made as the boiler test will have determined the evaporation per pound of wet coal. It is usual in scientific tests to give the results in terms of dry coal, and knowing the amount of wetness in the coal the evaporation per pound of dry coal is easily calculated. Suppose the boiler test showed that 7½ pounds of water were evaporated per pound of coal as fired and the chemist's figures show that the coal contained 10 per cent. of moisture; then the boiler really evaporated 7½ pounds of water from 0.9 pound of coal or

$$7.5 \div 0.9 = 8.33 \ pounds$$

of water per pound of dry coal. Another equally correct method would be to calculate from the chemist's figures the heat value per pound of coal as fired as to the heat value of the dry coal and the amount of moisture; that is, suppose the heat value of the dry coal is given us as 13,000 B.t.u. per pound and the wetness of the coal as fired is 10 per cent., the heat value per pound of coal as fired is

$$13{,}000 \times 0.9 = 11{,}700 \ B.t.u.$$

The important thing to look after is, that when the heat value of dry coal appears in the heat balance the evaporation per pound of dry coal must be used in calculating the heat imparted to the water and when the heat value per pound of coal as fired is used the evaporation per pound of coal as fired must be figured.

The available heat value of coal, having in view the conditions under which it is burned in a boiler, is not actually as much as the heat value ascertained by a laboratory test, for the reason that the hydrogen in the coal combines with oxygen to form steam and in a laboratory test this steam is condensed to water and the latent heat is given up. When burned under a boiler, however, the steam thus formed mixes with the other products of combustion and passes away as steam at a temperature above that of condensation; the latent heat in this steam is consequently not available and it is usual to deduct it from the heat value in the coal, calling the result the "lower" heat value. With ordinary coals the lower heat value is about 300 to 400 B.t.u. per pound less than the total heat value. It is customary nowadays to use the "lower" heat value in the heat balance for boiler tests and this, of course, makes the thermal efficiency higher than would be the case were the total heat adopted.

In considering steam-engine efficiency there are a considerable number of ratios each of which may be called the efficiency with respect to some standard of comparison, and it is again obvious that the term efficiency by itself means very little. Taking the general meaning of efficiency to be as stated at the beginning of this article, that is, the ratio between the energy supplied and the useful work done, the efficiency of a steam engine would appear to be the ratio of work done per pound of steam used divided by the total heat in one pound of the steam supplied, both being expressed in heat units. For example: let dry steam be supplied to an engine at 100 pounds absolute pressure and the steam used per horsepower per hour be 20 pounds. The total heat in one pound of dry steam is

found from the tables to be 1186 B.t.u. and the work done per pound of steam used is

$$\frac{33{,}000 \times 60}{20} = 99{,}000 \text{ foot-pounds} = \frac{99{,}000}{778}$$

$$= 127 \text{ B.t.u.}$$

and the efficiency by this method is

$$\frac{127 \times 100}{1186} = 10.7 \text{ per cent.}$$

This ratio, however, is not what is generally meant by the efficiency of a steam engine, as even in the case of a thermodynamically perfect engine the ratio would be less than unity. It is more useful, therefore, to compare the performance of an engine with that of the ideal engine working on some assumed conditions, the two most important of which are those known as the "Carnot" cycle and the "Rankine" or "Clausius" cycle. When the term thermodynamic efficiency or simply efficiency is used, the standard of comparison is the "Carnot" cycle, but if an ideal engine working on the "Rankine" cycle is the standard, the term "efficiency ratio" is used. The latter cycle is now generally accepted as the standard cycle for comparison and the "efficiency ratio" alone appears in the Institution of Civil Engineers' (England) standard method of tabulating steam-engine trials where the full formula for calculating this ratio is given.

Another important ratio relating to steam and gas engines but of a totally different nature is the "mechanical efficiency," which is the ratio between the work done on the piston and the useful work given off at the flywheel or the ratio between brake horsepower and indicated horsepower. The difference between these horsepowers represents work absorbed in friction in turning the engine, and the mechanical efficiency is a measure of the loss in obtaining power from the piston to the point where it is actually available for use and has no reference to thermodynamic considerations. To give an idea of the efficiency likely to be obtained in actual engines it may be said that, although the mechanical efficiency of a good engine may be from 85 to 95 per cent., the efficiency ratio lies usually between 0.5 and 0.6.

To turn to other machines it will be found that there is just as great a necessity to define what efficiency is meant when talking about their performance as is the case with engines or boilers. One sometimes sees tests of air compressors quoted where the efficiency without any qualification is given but where the volumetric efficiency is what is actually referred to. This is the ratio between the volume of air drawn through the inlet valves and the volume swept through by the piston of the air cylinder, and relates to the quickness in opening and closing of the valves or the lost motion in the machine and not the lost work. The lost work is measured by the mechanical efficiency and is of a precisely similar nature to the mechanical efficiency of an engine. In a steam-driven compressor the mechanical efficiency is the ratio of the indicated horsepower in the air cylinders to the indicated horsepower in the steam cylinders; and for a motor-driven compressor it is the ratio of the indicated horsepower in the air cylinder to the brake horsepower of the motor.

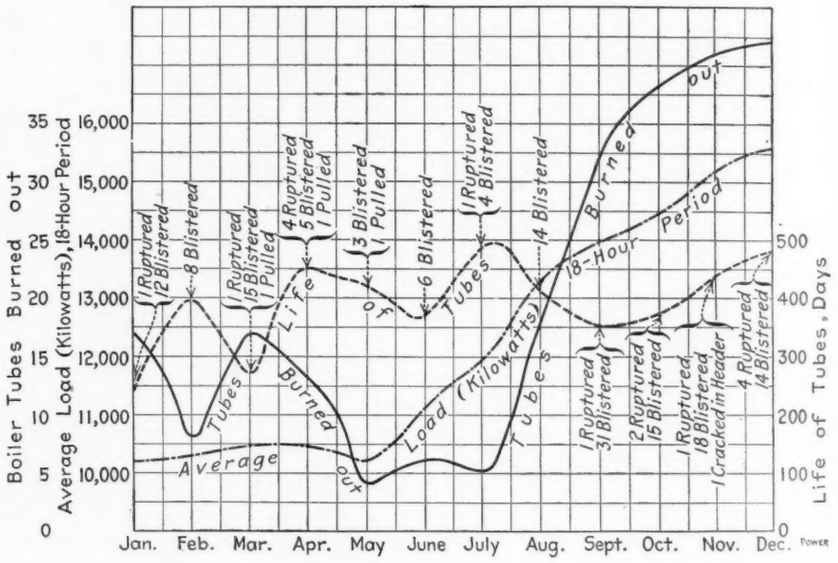
In considering the performance of an air compressor, however, there are other ratios which give useful information and enable different machines to be compared with an ideal standard, and as the term efficiency is often used in connection with these ratios it requires qualification. For instance, the power required to compress one pound of air from one pressure to another pressure when the temperature is maintained constant, that is, isothermal compression, can be calculated readily and is a convenient standard of comparison with the power actually found to be necessary in a compressor working between the same limits of pressure. The ratio of the work required for isothermal compression to the work actually taken is sometimes called the efficiency, but more correctly it is the efficiency compared with isothermal compression. For other purposes the power required to compress adiabatically, that is, without allowing any heat to be abstracted from or added to the air, is taken as the standard for comparison and the ratio obtained should be defined as the efficiency compared with adiabatic compression.

One could easily multiply instances of the various different ratios which are all called efficiency, but enough has been said to emphasize the point that it is a word which cannot properly be used without qualification.

Effect of Heavy Loads on Boiler Tubes

By Leroy W. Allison

Plotted from records of the past year's operation of a 15,000-kilowatt plant, carrying for the most part a railway load, the accompanying chart indicates the effect of peaks upon boiler tubes. The curves are deduced for 18-hour periods and are self-explanatory. The plant contains eighteen Babcock & Wilcox boilers, each rated at 550 horsepower and comprised of twenty-one sections of fourteen 4-inch tubes 18 feet long; the drums are 42 inches in diameter. To supply the three 5000-kilowatt units, the boilers are operated under a working pressure of 175 pounds, in groups of six; five are used for normal load, the sixth being held in reserve. Each boiler is fitted with a Peabody oil-burning furnace equipped with three burners. These burners fire forward from the bridgewall and steam is used as the atomizing agent. The boilers are provided with Babcock & Wilcox superheaters, designed for 100 degrees superheat, and California crude oil is used as fuel. This ranges in density from 13 to 15 degrees Baumé, and has a value, as fired, of approximately 18,000 B.t.u.


Boiler Tubes Burned out
Average Load (Kilowatts), 18-Hour Period
Life of Tubes, Days
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1 Ruptured 12 Blistered
8 Blistered
1 Ruptured 5 Blistered 1 Pulled
4 Ruptured 5 Blistered 1 Pulled
3 Blistered 1 Pulled
6 Blistered
1 Ruptured 4 Blistered
4 Blistered
1 Ruptured 31 Blistered
2 Ruptured 15 Blistered
1 Ruptured 18 Blistered 1 Cracked in Header
4 Ruptured 14 Blistered
Tubes Burned out
Average Load (Kilowatts) Tubes Burned out
18-Hour Period
Life of Tubes
Power

Effect of Load on Tubes

The ingineer at the sawmill wus cleanin' the biler and puttin' a kag of stable manure in the manhed when Parson Goodman kim along and stopped to talk a bit. He watched the manure go in the biler and all of a sudden exklaimed: "I never new before now what was meant by horsepower. I recken if you had a stable of 100 horses you would have a heap more power." An' the ingineer scratched his hed for a while an lowed he would.

Dimensions of Riveted Steel Pipe

By N. A. Carle

Charts showing the thickness of plate for riveted steel pipes of different diameters with various pressures, tensile strengths, factors of safety and efficiencies of joint. Examples are given illustrating the use of charts.

Riveted steel pipe is generally used to carry water from the source of supply to the point where it is to be utilized, at which point the discharge pressure is greater than the inlet pressure, due to the difference in elevation; or it may be used if water under pressure is to be conveyed between two points. The strength of the pipe must be increased as the head increases, and, unless a large factor of safety is allowed, unusual care must be taken in protecting the steel plates and rivets from rust.

The formula for the strength of riveted steel pipe is

$$P = \frac{2\,T\,t\,e}{D\,f}$$

where,

P = Safe working pressure in pounds per square inch;
T = Tensile strength in pounds per square inch;
t = Thickness of steel plate in inches;
e = Efficiency of joint in per cent.;
D = Diameter of steel pipe in inches;
f = Factor of safety.

The accompanying charts show graphically the thickness of steel plate for various diameters of pipe, working pressures, factors of safety, tensile strength of the steel plate and efficiencies of joints.

Fig. 1 is for pipe up to 60 inches in diameter carrying pressures from 50 to 300 pounds per square inch with factors of safety from 2.5 to 6. The tensile strength of the steel plate ranges from 45,000 to 70,000 pounds per square inch with efficiency of the joints from 50 to 85 per cent.

Fig. 2 is for pipe up to 45 inches in diameter carrying pressures from 200 to 1200 pounds per square inch with factors of safety from 2.5 to 6. The tensile strength and efficiencies of joints are the same as for the chart in Fig. 1.

EXAMPLE—What thickness of steel plate of a tensile strength of 60,000 pounds per square inch and an efficiency of joints of 70 per cent. will be necessary using a factor of safety of 5 for a pipe line 42 inches in diameter and carrying a pressure of 100 pounds per square inch?

Using the chart shown in Fig. 1, start with 42 inches diameter of pipe and read up to 100 pounds per square inch working pressure, then across to a factor of safety of 5, then down to 60,000 pounds per square inch tensile strength and across to 70 per cent. efficiency of joint and down to ¼ inch thickness of steel plate.

EXAMPLE—What pressure will a 30-inch pipe of ¾-inch steel plate stand with a factor of safety of 4 if the steel plate has a tensile strength of 50,000 pounds per square inch and a joint efficiency of 80 per cent.?

Starting with a ¾-inch thickness of steel plate and using the chart in Fig. 2, read up to 80 per cent. efficiency of joint, then across to 50,000 pounds per square inch tensile strength and up to a factor of safety of 4, then extend a line horizontally across until it intersects the ordinate marked 30 inches diameter of pipe. The value of the working pressure at the intersection will be found to be 500 pounds per square inch.

EXAMPLE—A pipe line 1600 feet in length and 60 inches in diameter has a gradual drop of 200 feet throughout its entire length. What thickness of steel plate of 55,000 pounds per square inch tensile strength should be used if the pipe line is to have a factor of safety of not less than 5 and a joint efficiency as follows:

¼ inch steel plate.....70 per cent.
9/32 inch steel plate.....75 per cent.
5/16 inch steel plate.....80 per cent.

and what will be the corresponding lengths of pipe made up of ¼-, 9/32- and 5/16-inch steel plates?

The pressure at any point will be that due to a head equal to 1600 ÷ 200, or ⅛ of the length of the pipe line from this point to the point of supply. Conversely, multiplying the head at any point by 8 will give the length of the pipe line from this point to the point of supply.

On account of the possibility of collapse from external causes, it is advisable that no steel plate shall be less than ¼ inch for pipes of this diameter and for service of this kind.

Starting with ¼ inch thickness of steel plate, Fig. 1, read up to 70 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength, then up to a factor of safety of 5 and then horizontally across to its intersection with the ordinate through 60 inches diameter of pipe. This gives a value for the working pressure of approximately 64 pounds per square inch, which is the limiting pressure for ¼-inch steel plate of 55,000 pounds per square inch tensile strength with a joint efficiency of 70 per cent. and a factor of safety of 5.

This pressure is reduced to its equivalent head in feet by dividing by 0.434, which gives 147.5 feet head. Multiplying this by 8 gives the length of ¼-inch steel pipe line as 1180 feet.

Starting with a 9/32-inch thickness of steel plate read up to 75 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength, then up to a factor of safety of 5 and horizontally across to its intersection with the ordinate marked 60 inches diameter of pipe. This gives a value for the working pressure of approximately 77.5 pounds per square inch, which is the limiting pressure for a 9/32-inch steel plate of 55,000 pounds per square inch tensile strength with a joint efficiency of 75 per cent. and a factor of safety of 5.

This pressure is reduced to its equivalent head in feet by dividing by 0.434, which gives 178.5 feet head. Multiplying this by 8 gives the length of pipe from the entrance to the end of the 9/32-inch steel plate as 1428 feet.

Starting with 5/16 inch thickness of steel plate read up to 80 per cent. efficiency of joint, then across to 55,000 pounds per square inch tensile strength, and up to a factor of safety of 5; then horizontally across to its intersection with the ordinate marked 60 inches diameter of pipe. This gives a value for the working pressure of approximately 91.5 pounds per square inch, which is the limiting pressure for a 5/16-inch steel plate having a tensile strength of 55,000 pounds per square inch and a joint efficiency of 80 per cent. with a factor of safety of 5. This pressure is reduced to its equivalent head in feet by dividing by 0.434, which gives 210.8 feet head. Multiplying this by 8 gives the length of pipe from the entrance to the end of the 5/16-inch steel plate as 1686.4 feet. The entire length of the pipe line is 1600 feet; therefore, no steel larger than 5/16 inch need be used.

The lengths of pipe line for each thickness may be found from the following:

Length of ¼, 9/32 and 5/16 inch	= 1600 feet.
Length of ¼ and 9/32 inch	= 1428 feet.
Length of 5/16 inch	= 172 feet.
Length of ¼ and 9/32 inch	= 1428 feet.
Length of ¼ inch	= 1180 feet.
Length of 9/32 inch	= 248 feet.

"Casey," says Mike, it bein' his first visit to the ice factory, "phwat koind of a ingine be that?"

Casey stuck his thumbs in the armholes of his vest and swelled up.

"That do be 'most a four-cylinder gas ingine," says he.

"'Most a four-cylinder," says Mike, peerin' at the critter; "do anny of her cylinders be busted?"

"No," explains Casey, "they're all o' thim sound'n tight, but wan o' thim is missin' most o' the toime."

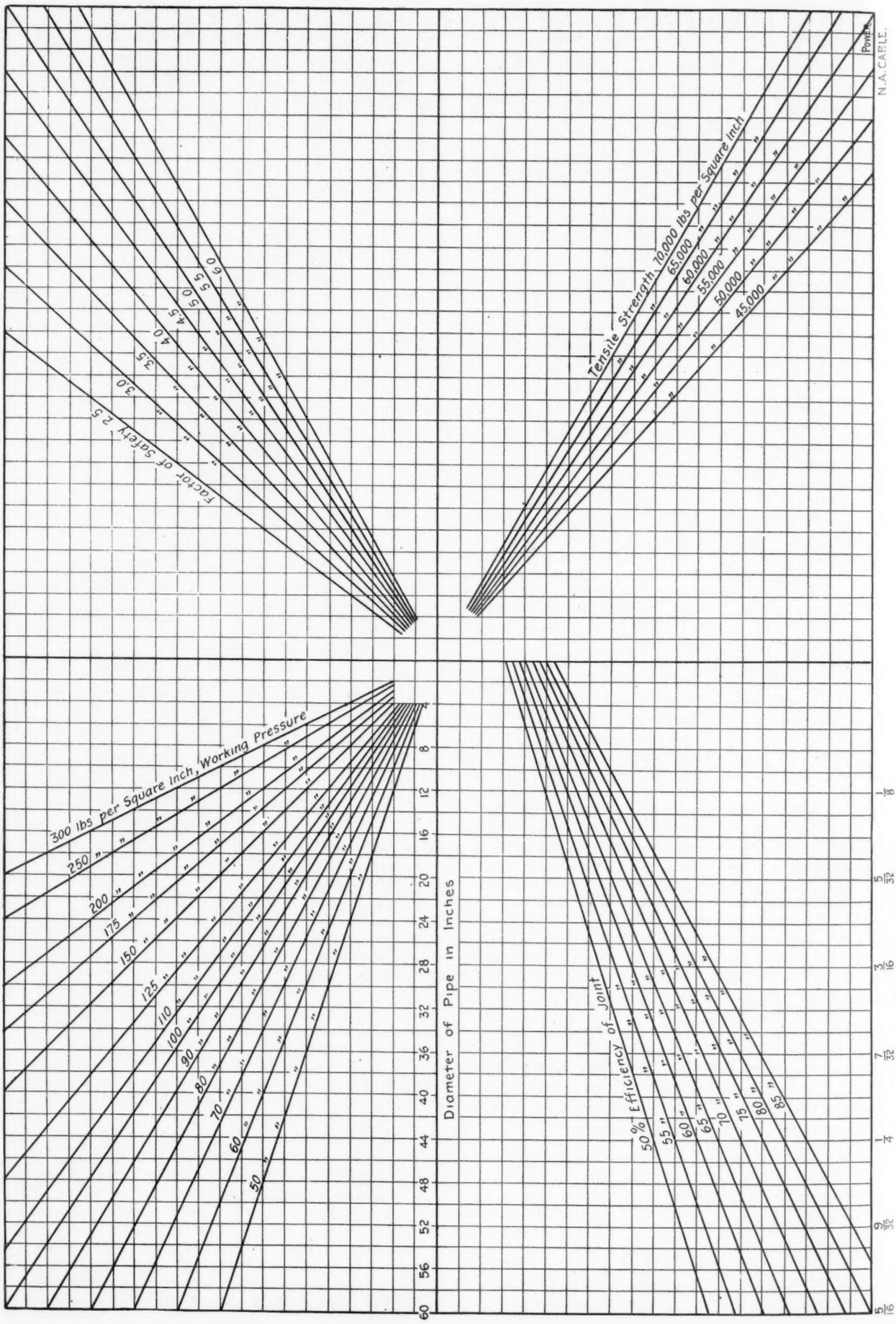

Factor of Safety 2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
Tensile Strength 70,000 lbs per Square Inch
65,000 " " " " "
60,000 " " " " "
55,000 " " " " "
50,000 " " " " "
45,000 " " " " "
Power
N.A.CARLE
300 lbs per Square Inch, Working Pressure
250 " " " " "
200 " " " " "
175 " " " " "
150 " " " " "
125 " " " " "
110 " " " " "
100 " " " " "
90 " " " " "
80 " " " " "
70 " " " " "
60 " " " " "
50 " " " " "
Diameter of Pipe in Inches
4 8 12 16 20 24 28 32 36 40 44 48 52 56 60
50% Efficiency of Joint
55 " " " "
60 " " " "
65 " " " "
70 " " " "
75 " " " "
80 " " " "
85 " " " "
1/8 5/32 3/16 7/32 1/4 9/32 5/16
Thickness of Steel Plate in Inches.

FIG. 1. CHART FOR USE WITH PRESSURES FROM 50 TO 300 POUNDS PER SQUARE INCH

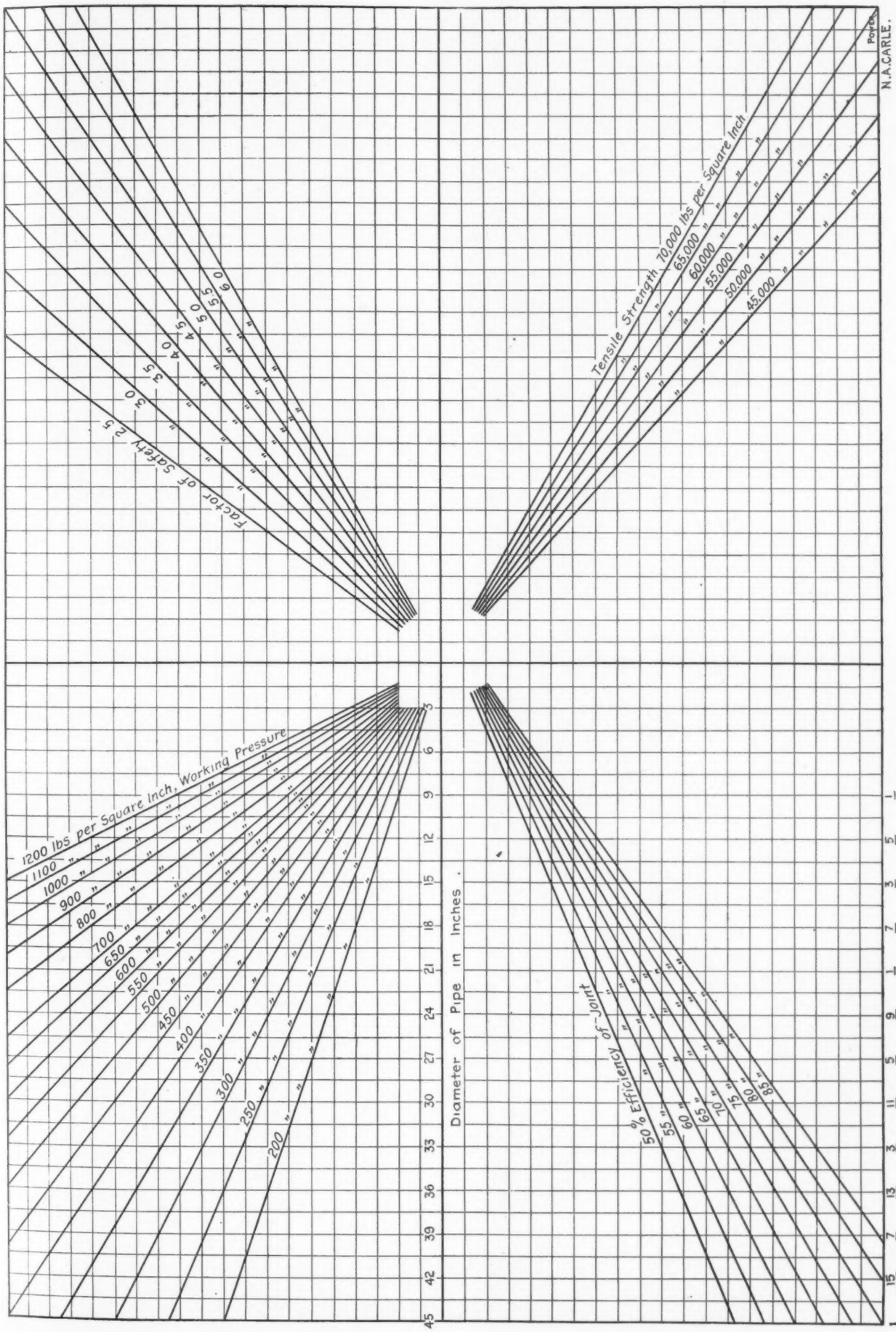


FIG. 2. CHART FOR USE WITH PRESSURES FROM 200 TO 1200 POUNDS PER SQUARE INCH

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Repairing Induction Motors

By R. H. Fenkhausen

Rotor Repairs

After the shaft and bearings have been put in first-class condition, the rotor should be carefully examined to see if the "winding" is damaged. The paper in the slots inclosing the rotor bars should be tried with a knife point, and if so badly charred that it chips off when

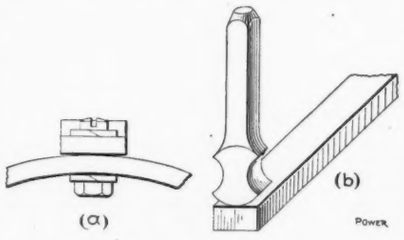


Fig. 14. Bar Connection

touched, it should be renewed. The mere fact that the paper was charred would indicate only a slight decrease in the starting torque, which would not be of any practical harm to the motor. Charred paper, however, is usually the effect of local heating at the joints between the bars and the end rings, caused by loose bolts, and as the repair of this trouble requires the removal of the bars in order that the contact surfaces may be cleaned, the renewal of the paper insulation on the bars entails only a very small amount of additional work and makes a proper job of the repair, instead of a makeshift.

The heating caused by poor contact

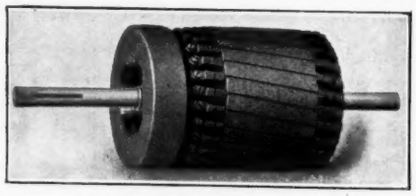


Fig. 15. Rotor with Skewed Slots

between the rotor bars and short-circuiting rings is liable to lead to serious damage to the entire motor if not corrected. The ends of the stator coils outside the slots lie very close to the rotor and are liable to be so badly charred as to necessitate a complete rewinding of the stator.

Squirrel-cage Rotors with Bolted Bars

The bolts should all be removed and the bars taken out of the slots. The short-circuiting rings should then be thoroughly cleaned with sandpaper and the outside circumferences "tinned." The solder should be applied to the ring while the latter is hot, and, after the entire surface has been coated, the "tinning" should be wiped with a piece of cloth before the solder has set. This will insure a coating of uniform thickness all around the ring.

The bars should be cleaned and all charred paper scraped off them and also from the walls of the slots in the core. The under surfaces of the bars should then be "tinned" at each end for a distance equal to the width of the short-circuiting ring, and wiped smooth, like the rings. The object of "tinning" the contact surfaces between the bars and rings is to prevent oxidation in case of any subsequent slight heating due to temporary overloads. The "tinned" surfaces tend to unite when heated and form a soldered joint.

Before "tinning" the bars the contact surfaces should be tried on the ring to determine whether the bar is concaved to fit the ring, or flat. Fig. 14 shows at *a* an exaggerated view of the scanty contact found in rotors when the makers do not take the trouble to give the bars the proper shape. Small motors having rotors of small diameter with comparatively few bars are most liable to trouble from this source. Large motors usually have bars of approximately the same size as those used in the smaller motors, but a much larger number of them, and, owing to the large diameter of the end rings, the amount of curvature under a single bar is practically negligible.

If the contact is found to be bad, due to this cause, a steel swedge should be made having a face curved to correspond to the curvature of the ring, and all the bars should be given a blow with this before "tinning," as indicated at *b* in Fig. 14, care being used that the swedge is held level so that the bar will be uniformly indented. For rotors having skewed slots, as shown in Fig. 15, a jig should be made before swedging in order that all bars may be held at the same angle that they will have with reference to the short-circuiting rings when the rotor is reassembled.

Methods of Bolting Bars

There are several methods of bolting the rotor bars to the short-circuiting rings, each of which has its advantages. The four methods in most common use are illustrated in Fig. 16. The method shown at *a* was formerly used on almost all motors. A large bolt with a nut and spring washer inside the ring gave ample clamping power without danger of stripping the threads on the bolt. Later designs of rotors are usually fitted up as shown at *b*, *c* or *d*. On account of the smaller bars now commonly used, there is no room for a large bolt, and a small 10/32 machine screw is usually employed.

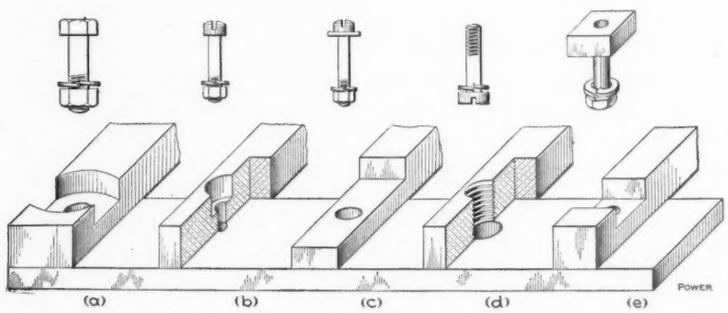


Fig. 16. Forms of Rotor-bar Ends for Bolting

It will be noted that the three joints shown at *a*, *b* and *c* are made with the nuts inside the ring and the bolt heads outside. This construction is the most accessible, except on large motors, but is open to the very serious objection that a loose, broken or burned-off screw or bolt will naturally be thrown outward by cen-

trifugal force and will catch on the stator coils and seriously damage them. Cases are on record where a complete set of new stator coils has been necessary as a result of a broken screw. The construction shown at *d* is designed to eliminate this objection and is used on a large proportion of the motors now manufactured; two bolts at each end of each bar are used on the larger sizes of motors. The disadvantage of the latter construc-

FIG. 17. DRILL BIT

tion lies in the fact that the thread for the screw is tapped into the bar itself, and as there is no room for a lock nut, reliance must be placed on a spring washer to prevent the bolts from becoming loose.

Where there is much vibration, trouble is experienced from loose bolts, which has led one manufacturer to upset the ends of the bolts. This effectually locks the bolt but when it becomes necessary to repair the rotor it is practically impossible to remove the bolts without stripping the threads out of the bars. The screws cannot be drilled out, owing to the difficulty of holding a drill central on a steel screw; it will run off into the softer copper. The limited diameter of the bars makes it impossible to retap them for a larger size of screw when stripped.

Two methods of repairing the rotor are available. The first is to counterbore the bars, as shown at *b*, Fig. 16, and use fillister-headed screws with nuts and spring washers inside the ring. A pin

FIG. 18. INSULATION CUTTER

drill for counterboring is shown in Fig. 17; this can be easily turned up in a lathe out of a piece of tool steel. This method of repair, though the easiest, is open to the objection previously mentioned, that a loose bolt can damage the stator winding. A better method is illustrated at *e*, Fig. 16. The bars are sawed or milled out somewhat as shown at *c*, but instead of the screw head being outside it is placed inside and a special square nut fitted into the notch cut in the bar; a spring washer under the head of the screw serves as a lock. As the nut does not carry current it may be made of steel, and may be properly tightened without danger of stripping the threads.

PAPER INSULATION

The new paper insulation should be of red rope paper or bond paper, 5 to 8 mils thick. It should be cut long enough to inclose the bar to within 3/16 inch of each end ring, and wide enough to cover five sides of the bar, which will give a lap on one side to allow pasting. The paper should be cut from the roll in strips wide enough to make the length of the individual bar wrappers, with the aid of a straight-edge, and then cut into the proper widths with a photographic print trimmer, such as that shown in Fig. 18.

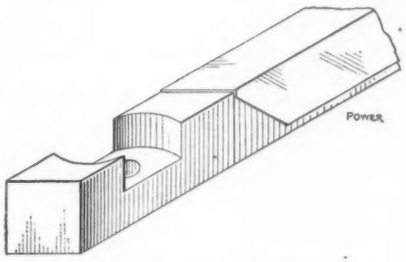


FIG. 19. PAPER SHEATH

Each paper cell should be creased and folded around the bar, and the corners clipped off as shown in Fig. 19 to facilitate the entrance of the cells into the slots, and prevent the corners of the paper from catching on the laminations of the core.

The overlapping ends of the paper cells should next be pasted into place and the bars inserted in the rotor slots. The double thickness of paper should be on the bottom of the slot to prevent the lapped ends of the paper from becoming loosened by centrifugal force and flying out into contact with the stator winding. This would, of course, do no damage, but would cause a rustling noise, very annoying in most locations.

After the bars are all in place, the end rings should be inserted, and two diametrically opposite bars bolted firmly to the rings at each end. A thin "feeler" should then be tried between the rings and bars to insure that a condition similar to that illustrated by Fig. 20 has not been brought about by too much paper in the bottom of the slots. If trouble from this source is found, the paper cells must be reversed so as to bring the double thickness of paper on top of the bar instead of underneath.

The bolts should then be drawn tight and the spacers which prevent axial movement of the bars inserted at equidistant points around the ring. These spacers consist of small sheet-metal strips clamped under the nuts which hold the bar, as shown in Fig. 21. It will be noticed that the squirrel cage is grounded

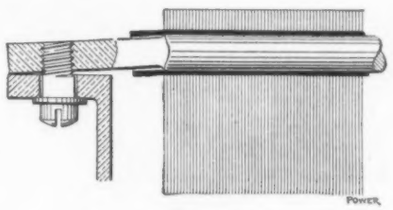


FIG. 20. A POOR JOINT

at these points, but, owing to their location, the effect is negligible.

SOLDERED SQUIRREL-CAGE ROTORS

Owing to the soldered joints between bars and end rings, trouble from loose contacts is seldom encountered in this form of rotor, except as the result of extreme overloads such as occur in planing mills or other wood-working establishments, for which service the bolted construction is preferable.

In case repairs are necessary to this type of rotor, the short-circuiting rings must be heated with a gasolene torch until the solder melts and permits the rings to be pried off. The bars should then be cleaned, "tinned," reinsulated, as described in the discussion of bolted rotors, and replaced in the slots. The rings should be thoroughly cleaned and all paint removed before retinning. If this is neglected, the paint or varnish will run into the joints when the ring is heated and prevent the solder from making a good contact. After the rings have been cleaned and retinned all over, they may be slipped into place on the bars.

In the earlier forms of soldered end rings, the openings for the bars were punched out, leaving only a thin edge of metal available for the soldered joint. It is very difficult to make a good joint

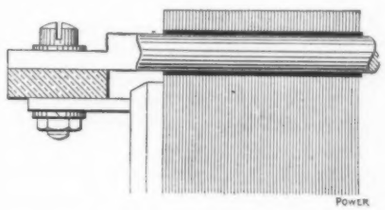


FIG. 21. A GOOD JOINT

with these rings unless the entire structure be dipped into the solder. This is best accomplished by the use of a shallow annular trough of clay, or of sheet iron lined with clay. The solder may be melted by means of several torches and the rotor dipped into the molten solder to the required depth, as shown in Fig. 22. Later forms of end rings have the metal

only partly punched from the openings and bent back to form lips and spacers between the rings, as indicated in Fig. 23. These lips give a comparatively large contact surface for soldering, and the rings may be soldered with an iron, provided, of course, that one ring be placed at a time, in order to give access to all sides of the bars.

Riveted Squirrel-cage Rotors

In case it becomes necessary to remove the rivets from a rotor of this type, they should not be chipped out, because hammering a steel rivet in a soft copper bar will enlarge the hole and prevent proper contact with the rivet when the rotor is

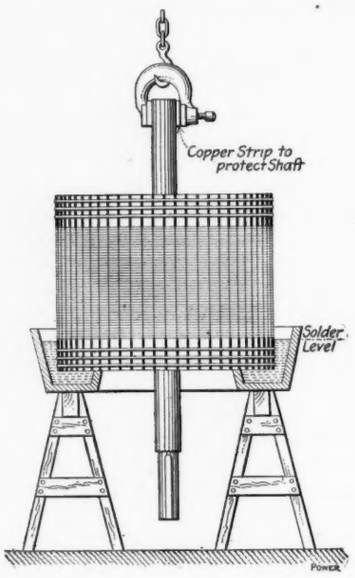


Fig. 22. Soldering Rotor Connections

reassembled. The rivets should be removed by filing off the heads, or by drilling out the countersunk heads if these be used. After "tinning" and reinsulating the bars, as previously described, they should be attached to the end rings by bolting, one of the methods shown in Fig. 16 being employed.

Wound Rotors

Although grounds on a squirrel-cage rotor are of little consequence, two or more grounds on a wound rotor may lead to serious trouble. Rotors of this type are almost invariably equipped with three-phase windings, usually "star" connected. The effect of grounds on a rotor of this type can best be illustrated by an extreme case. Suppose that three grounds should occur simultaneously, at the points *A*, *B* and *C*, Fig. 24; the entire winding would be short-circuited upon itself and run as a squirrel-cage rotor. It is evident that a change in the external resistors R_1, R_2 and R_3 will have no effect on the speed of the motor, which will run at full-load speed irrespective of the position of the controller handle.

Though this is an extreme case, the effect of two or more grounds, wherever located in the rotor winding, is to take the speed control of the motor out of the

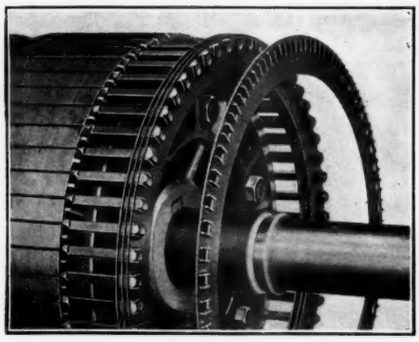


Fig. 23. Bolted Rotor Bars

operator's hands to a greater or less degree, depending on the amount of the winding short-circuited by the grounds. Whenever a motor runs above its normal speed for a given load and controller position it may be taken as evidence of grounds. As the slip rings and brush rigging are more liable to become grounded than the rotor winding, the leads from the winding to the slip rings should be disconnected before testing for grounds.

A short-circuit will produce an effect similar to that of two grounds; but it is a very difficult fault to locate, owing to the extremely low resistance of the wind-

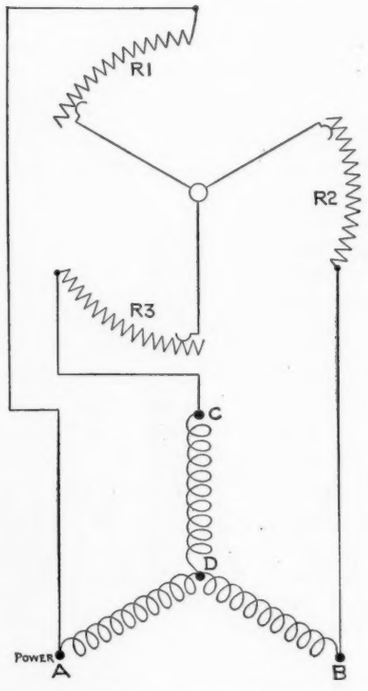


Fig. 24. Wound-rotor Connections

ing. It is most liable to occur between the two bars in one of the slots, where they happen to belong to different phases, and seldom results in a ground.

Open circuits are of rare occurrence, owing to the heavy conductors used, and even should one occur it could easily be located. When a short-circuit is suspected the common junction at *D*, Fig. 24, should be opened to allow testing for crossed phases. By measuring the resistance of each phase with a sensitive Wheatstone bridge, short-circuits can be detected.

Wound rotors for service requiring high torque or where the controlling apparatus is located some distance from the motor are wound with coils similar to those used on the stator, the only difference being that the rotor coils are

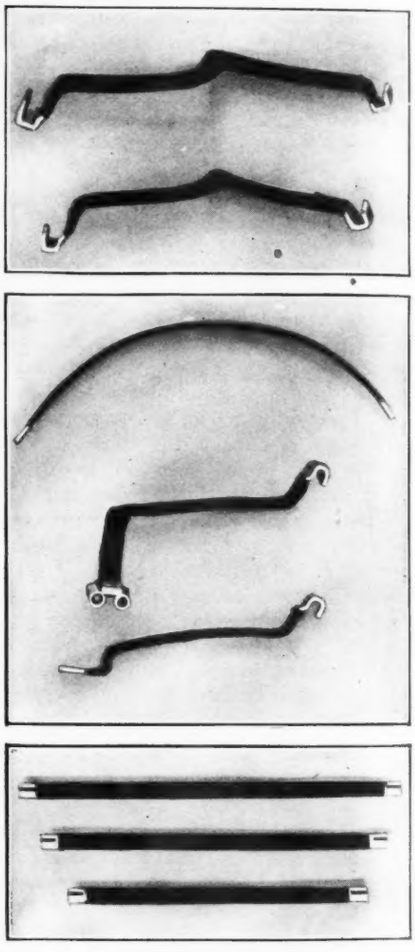


Fig. 25. End Connectors, Winding Terminals and Rotor Bars

placed in slots on the outside circumference of the core, while the stator coils are placed in slots on the inside circumference of the core. Coils of this type are of high resistance and many turns and the rotor voltage is often as great as that impressed on the stator winding. Owing to the similarity between a stator winding and a rotor winding of this character, the repair of such rotor windings will not be treated in this article; the full instructions which will be given in the article on the repair of stator windings will apply equally well to high-resistance rotors.

Bar Windings for Rotors

Most of the wound rotors for multi-speed service now in use are wound with heavy bars or strips similar to those used

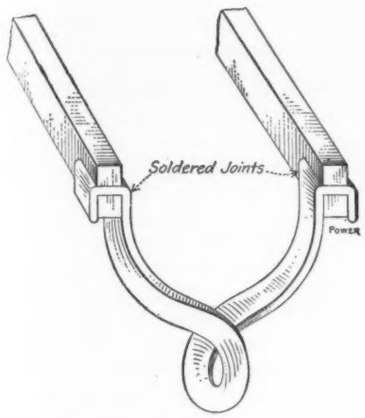


Fig. 26. Wound-rotor Bar "Coil"

in a squirrel-cage rotor, but two bars are usually put in each slot. These bars are connected at the ends into regular "coils" by means of pieces of copper strap, known as end connectors. This material is usually only half as thick as the bars which it connects; it is, therefore, made twice as wide in order to get the necessary cross-section. Fig. 25 shows long and short bars and end connectors and also the terminal leads for the winding. Fig. 26 shows the method of grouping two bars and a connector to form a one-turn coil. It will be noted

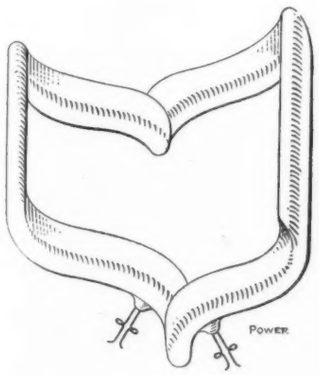


Fig. 27. A Stator Coil

that the finished "coil" resembles the involute form of stator coil shown in Fig. 27.

The end connectors are soldered into slots cut in the ends of the rotor bars and the three free terminals of the winding are carried to the slip rings. As the repair of a bar-wound rotor of this type seldom calls for the renewal of anything except the insulation on the bars and end connectors it is merely a matter of replacing things and reconnecting in the original manner.

Balancing

After repairing a wound rotor it should be tried for balance; the less symmetrical character of the winding makes it more liable than the squirrel-cage type to be reassembled out of balance. The most accurate method is illustrated in Fig. 28. Two parallel rails are set up perfectly true and level on stout posts and the rotor is hoisted up and placed on the rails with a large ring slipped over each end of the shaft, as shown. These rings permit far more accurate balancing to be done, as they allow the rotor to revolve much more easily than it would if the shaft were laid directly on the parallel rails.

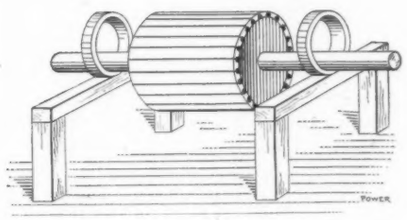


Fig. 28. Balancing Ways

The rotor will roll until the heavy side is at the bottom. A piece of wet clay should be pressed against the inside of the spider on the light side and its weight adjusted and location changed until the rotor shows no tendency to rotate, no matter in what position it is placed. Then the clay is weighed and a piece of metal fastened in its place by means of a tap bolt; the weight of the metal and bolt together must equal that of the clay.

Collector Rings and Brush Holders

Trouble at the collector rings is usually due to defective insulating bushings

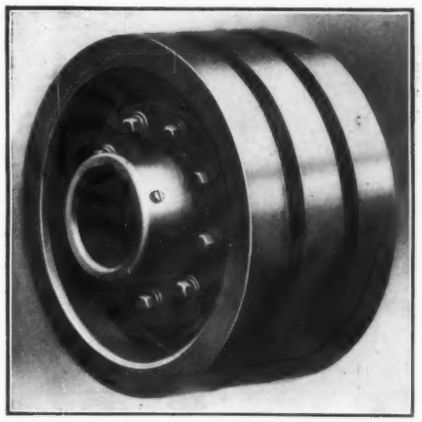


Fig. 29. Three-phase Slip Rings

around the bolts which hold the ring structure together. It is usually caused by vibration, which loosens the bolts and allows them to "work," thereby wearing out the insulation. After renewing the bushings the rings should be drawn together tightly and lock washers placed under the bolts. Fig. 29 shows the construction of a set of rings.

Fig. 30 shows a typical set of pivoted brush holders. Flexible copper shunts or

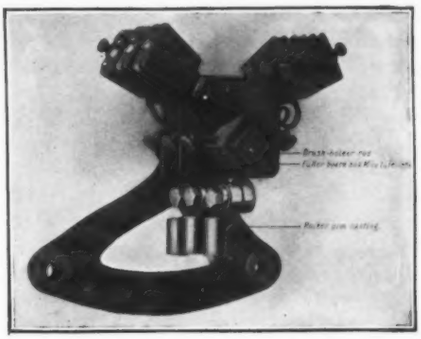


Fig. 30. Rocker-arm and Brush Holders

"pigtails" are used to carry the current from the brush box to the terminals. If one of these shunts should be broken, the current would be forced to travel through the hinge pin, which will heat up until it sticks and prevents the brush from maintaining contact with the ring. The carbon brushes used with this type of motor usually have copper-wire gauze molded into the brush to increase its conductivity.

These brushes should be fitted to the slip rings with sandpaper in the same manner as those on a direct-current motor, but, owing to the fact that the long axis of the brush is radial to the shaft, a condition such as that illustrated in Fig. 31 may exist when the sandpaper is removed. If the sandpaper is 1/16

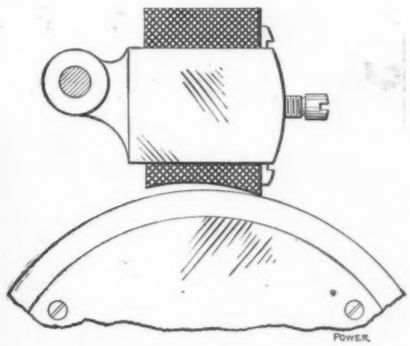


Fig. 31. Improper Brush Setting

inch thick, the hinge edge of the brush is liable to be over 1/32 inch clear of the ring, due to the position of the hinge.

To correct this it is necessary merely to loosen the clamping screw and slide the holder upward on the brush until both edges touch the ring as they must to obtain good contact.

When timber shrinks, hangers will get loose, allowing belts to pull the shaft out of line. This can be prevented by driving in a small lag screw at the heel or toe of the hanger.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Repairing a Broken Engine Frame

By H. T. Melling

The breakdown and repair of a 50-horsepower gas engine came under the writer's observation some time ago. The engine was a single-cylinder single-acting one, working with a similar engine of 100 horsepower, both engines being connected to the same shaft by rope drives off the flywheels.

The engines had been at work about two years, giving entire satisfaction, when the accident occurred. The connecting-rod bolts on the big end of the 50-horsepower engine broke and, the piston being blown partly out of the cylinder, when the crank next came around it lifted the connecting rod so far that it broke through the top of the piston barrel and broke the cylinder liner and the front of the main frame. See Fig. 1.

It was first thought that the breakage of the main frame would necessitate a new casting because the front of it formed a water-tight expansion joint with the cylinder liner. However, it was decided to order from the makers only a new cylinder liner and piston.

The two broken pieces of the main frame were placed in position and a pattern made for a patch to cover the entire surface of the front end of the frame, as illustrated by Fig. 2; the casting was made of brass in order that it might be more elastic. This was bedded down to the surface over the broken part, six ¾-inch machine bolts on each side clamping it down to the main frame. Before the patch was put on, the new cylinder liner was put in place, with a rubber ring on the end of the liner, which packed the expansion joint. The broken pieces of the main frame were then put in position, a thin coating of red-lead putty was smeared over the entire surface and the patch was drawn down to its place by the bolts.

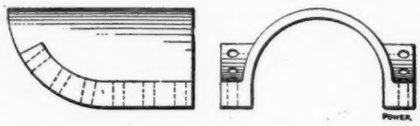


Fig. 2. The Frame Patch

Fig. 1. The Engine Immediately After the Accident

The oil inlet to the piston was placed four inches further back than it had originally been and a force-feed pump put on in place of the old lubricator.

The connecting rod was straightened and the bolt holes of the large end reamed out larger. It was evident from inspection of the old connecting-rod bolts that they had been weakened by the constant knocking of the big end, causing them to stretch to their elastic limit and then broken, after crystallization, at the finish of the thread. The new bolts were made of the best hammered iron and instead of being made of uniform diameter were turned down as shown in Fig. 3 to the diameter of the bottom of the thread, to make them more elastic.

The practice of having both engines drive the one shaft was abandoned and each was given a separate load.

Fig. 3. Connecting-rod Bolt

After the engine had warmed up, the bolts on the patch were thoroughly tightened up and it was found to be a most satisfactory repair.

Rocker Arms for Poppet Valves

By A. M. Levin

Some time ago, upon examining the inlet valve of an 18x24 gas engine in order to ascertain, if possible, the cause for its general bad action and persistent leaking, it was discovered that the bore of the valve-stem guide had become badly worn out of round. Since the valve guides of engines of this class as ordinarily arranged do not usually wear perceptibly, and since everything pertaining to this valve gear appeared to be arranged according to common practice and to be in proper working order, it proved somewhat of a puzzle, at first, to think of a good cause for the abnormal wear. It was promptly observed that the little roller on the end of the rocker arm, which engages with the end of the valve stem in pushing the valve open, had become stalled on its pin; but, as these rollers frequently are and ordinarily can be stalled without bad effects, there was no suspicion at first that this circumstance had any bearing on the case.

Finally, however, after closer observation, it became clear that there might be a right and a wrong way of laying out the valve-rocker motion, or, perhaps more

cautiously stated, two right ways, of which one is more liable to go wrong than the other, and that that little roller might have a material influence on the wear of the valve guide. The facts of the matter are very simple and evident, but as it often is the simple and evident things that are overlooked and apt to cause trouble, it may not be waste of time to dwell upon this little kink.

Figs. 1 and 2 indicate two ways for laying out the valve-rocker motion, both of which are apparently good. Fig. 1 represents the way in which the rocker motion was arranged in the case just cited. Observe how beautifully close to the center line of the valve stem is the force acting from the roller, in all positions of the valve. In Fig. 2, however, which represents the more common way of laying out the rocker motion, the force applied on the end of the valve stem shifts between the point *E*, corresponding to the closed position of the valve, and the point *H*, corresponding to its position when fully open. To all appearances the layout in Fig. 1 would be fully as suitable as that illustrated in Fig. 2, but there is a rub due to the friction between the roller and its pivot pin; because if it does not slide at all on the end of the valve stem the roller must, with the first layout, rotate through the angle *A*—*O*—*B*.

In estimating the pressure on the roller pin we find that a 6-inch valve, having a spring tension back of it of, say, 7 pounds per square inch of the valve area, calls for a maximum force of 200 pounds to simply open the valve slowly. To overcome the inertia of the valve at full speed there will be added to this force another amounting easily to 5 pounds per square inch of the valve area, or, in total, 125 pounds. We have thus, in all, a pressure of 325 pounds on the roller pin, which would not be so bad excepting for the fact that the angle through which the roller rotates is, at best, hardly great enough to allow a proper lubrication of the pin.

The effect of the friction between the roller and its pin in the arrangement of Fig. 1 will be a force *c* or *d*, acting laterally at the end of the valve stem, and, of course, the greater the distance to the valve-stem guide, the greater will be the friction between the stem and the guide caused by this force. It can, therefore, be expected that the guide will wear appreciably if it should happen that the roller got stalled on the pin. Now, in the layout in Fig. 2 it is evident that the roller does not revolve on the pin; it simply rolls on the end of the valve stem. Strictly speaking, it should revolve or slide to the extent of compensating for the versed sine of the angle *A*—*O*—*N*, probably not more than 1/64 of an inch each side of the center line of the valve stem; but as that small amount is not much more than the side motion which the freedom of the valve stem in the guide will allow to the stem, there will, practically, be no motion between the roller and its pin.

The difference in principle between the arrangements in Fig. 1 and Fig. 2 is illustrated in Figs. 1-a and 2-a. The forces acting on the valve stem when in its top position resolve themselves, in Fig. 1-a, into the central force F_1, the lateral force C and the turning moment $T_1 T_1$. In Fig. 2-a there are the central force F_2 and the turning moment $T_2 T_2$. If, in Fig. 1, it is assumed that the roller, being stalled on the pin, slides on the end of the valve stem, and that the sliding friction becomes as great as 25 per cent. of the normal pressure, with a total valve pressure of 320 pounds, the force C normal to the guide becomes 80 pounds and the turning moment $T_1 T_1$, approximately 70 pound-feet. The turning moment $T_2 T_2$ would, under all circumstances, be approximately only 3 pound-feet. Under ideal conditions as to lubrication of the valve-roller pin, the arrangement in Fig. 1 would not be much worse off than that in Fig. 2, but, as practical conditions effectively exclude such ideal lubrication, the second arrangement will be by far the safer of the two.

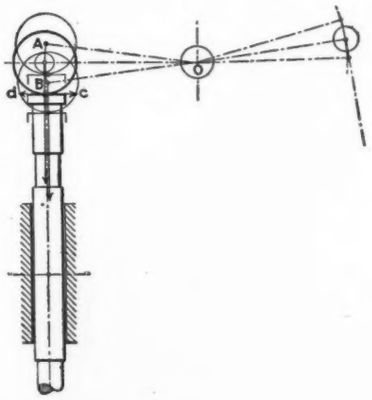


FIG. 1

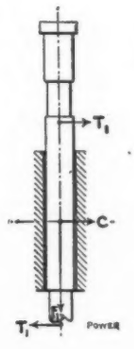


FIG. 1-a

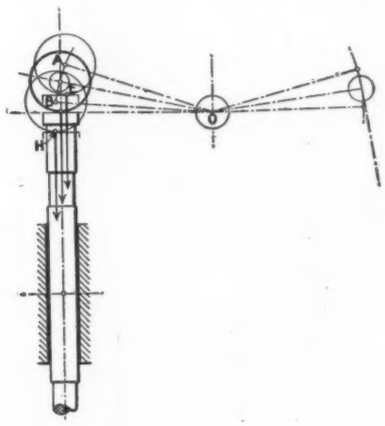


FIG. 2

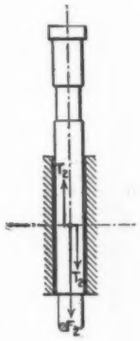


FIG. 2-a

A Satisfactory Plant

By H. T. Westwood

For the past four years I have been operating gas engines and suction and pressure producers, and my experience has been very satisfactory. The plant I am now running contains a suction producer and a two-cylinder vertical engine rated at 110 horsepower. Previous to the installation of the gas plant the works were driven by an automatic cutoff steam engine of the same rating as the gas engine.

Our load is very irregular. We have an air compressor rated at 48 horsepower working against 100 pounds pressure and it is cut off when the pressure reaches 100 pounds and cut on again at 90 pounds pressure. It goes on and off 200 to 300 times in a day. When the steam engine was driving the plant, the voltage at the switchboard would drop 12 volts every time the compressor went on. This made the lights so poor that we had to install another engine to drive the dynamo. With the gas engine, the voltage does not fall two volts when the compressor goes on, regardless of the other load.

The wrist-pin brasses in this engine have been tightened up only once in the last six months and the crank-pin brasses twice. We have a gage glass attached to the crank case, putting the level of the oil in full view of the operator all the time.

I will admit that it requires a man of more skill and ability to run a suction gas producer and engine than to run a steam plant, but a gas plant does not require as much attention while running as a steam plant. We have not had a breakdown, or even a stop to exceed 20 minutes, in the last 17 months.

The igniters are supplied with current from the dynamos at 110 volts and they run three months without changing.

My experience with the gas engine convinces me that a level head, good, clean gas and the right cylinder oil are all that is necessary to make it the cheapest and best prime mover so far devised.

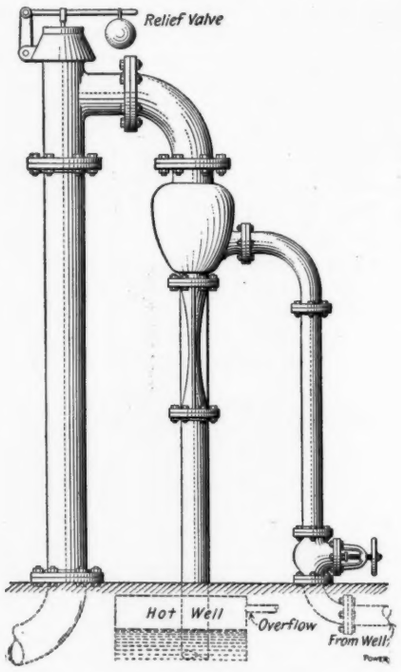
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Pumpless Condenser Installation

In Greenwood, Miss., can be seen a condensing outfit requiring no circulating or vacuum pumps.

It is supplied with water from an artesian well which gives a pressure at the top of the ground of 30 pounds. This water is carried to the supply pipe and is controlled by a valve just above the ground. All that is necessary to start the condenser is to open the valve and start the engines. A vacuum of 23 inches is maintained without any trouble.



PIPING OF CONDENSER

I would like to know if anyone else has had any experience with this kind of a condenser arrangement.

H. T. FRYANT.

Jackson, Miss.

Filing Power Articles

Various schemes for binding or filing the vast amount of data and information contained in POWER have appeared in its pages, but none that I have noticed seem to fill the bill for my use. Binding the different volumes together is open to the objection that the data or information on any subject is difficult to locate. I have devised a system of filing the information contained in POWER which is very satisfactory, as any particular article, or series of articles, is easily found.

Each magazine, after being read, is taken apart by removing the binding wires and all information or articles of interest are laid aside, and the remainder of the journal is thrown away. At the office outfitters' I procured an oak letter file about 14 inches square and 24 inches long, provided with drawer, folders to hold the letters and alphabetically lettered division cards, similar to an ordinary card catalog. All information or articles relating to any one subject, as, for instance, "direct currents," would be filed in a folder marked "Direct Current" and filed under "E," for electricity. Should two or more articles on different subjects appear on the same pages, the titles are written or printed on the first page and all held together by a wire fastener; then the group is filed under the subject of any of the articles.

I also keep a card catalog in which appears the complete title and author of every article on file. The different titles are separated under the several subjects as in the main file. The card catalog is necessary on account of numerous articles which do not appear in their proper folders, as explained. For example—there might be an article on fuels, another on heating and ventilating, and still another on refrigeration all on the same page, which could not be separated. These pages would all be fastened together and filed, say, under "Fuels" in "F." On the first page at the top margin would be written the title of the article on heating and ventilating and also of the one on refrigeration; then in the card catalog under "Heating and Ventilating" would appear the title of the particular article with reference to the folder on fuels, and likewise with the article on refrigeration.

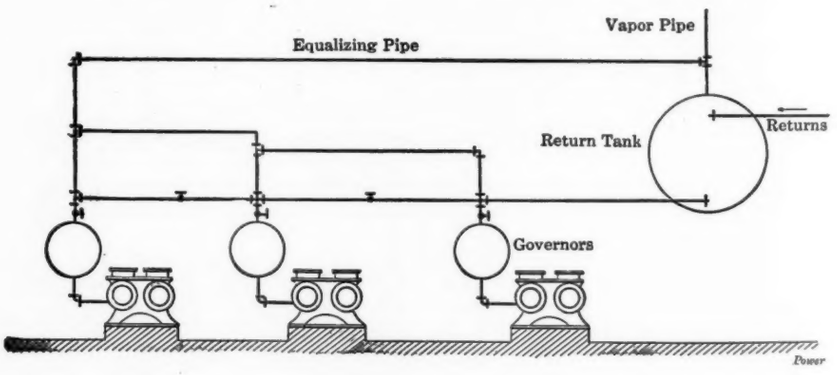
The letter file referred to may be obtained at almost any office outfitters' for from $3.50 up, depending upon the finish of the case. The folders are 9x11½ inches, necessitating trimming the pages of POWER on two sides.

B. A. PARKS.

Grand Rapids, Mich.

Defective Return System

I was recently called on to remedy a defect in the return system of a large heating installation, the trouble being that the condensation returned intermittently and at times filled the tank and flooded back into the heating returns. The plant is equipped with a receiving tank to which all condensation from the heating system and the various manufacturing processes is returned, and the three feed pumps force the water from the tank to the boilers.



PIPING OF RETURN SYSTEM

Each pump has a receiver containing a float which controls a steam valve by which the speed of the pump is governed and as long as the condensation is returned uniformly one pump would do the work. However, at times the returns came back in large quantities and if the

attendant was not near to start another pump an overflow occurred. A larger tank would have solved the difficulty, but this was out of the question for want of room, and the connection shown in the illustration was resorted to.

The valve on each pump governor was left open and those between them closed so that as long as the water returned at a normal rate only the first pump was in operation, but when it was taxed beyond its capacity the water would rise in the tank and pass over to the second pump and, if it continued to rise, would pass on to the third one, each starting automatically in its turn.

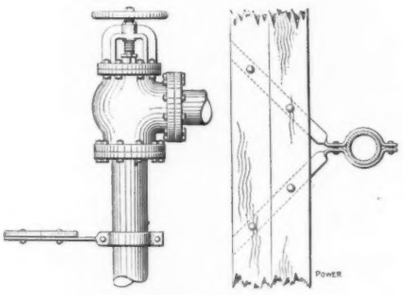
By closing the valve to the first pump governor and opening the one between the first and second governors, the last two pumps can be run in tandem, or the valves can be changed to operate any one alone. The piping, as shown, should be as large as the suction pipe out of the tank, but the "equalizer" only serves to prevent an air lock and may be very small.

LEWIS C. REYNOLDS.

Willard, N. Y.

Platform Attached to Pipe

Valves of various kinds are found rather hard to get at in steel mines when necessary.



DETAILS OF PLATFORM

The accompanying illustration shows how a platform can be attached to a pipe by means of a clamp, upon which a man can stand while at work.

E. H. MARZOLF.

Bellaire, O.

Topics for Discussion

Is water hammer due to the presence of water lying along the bottom of the lowest part of a line of piping, or is it due to a conflict between the cold air and the inrushing hot steam which causes the violent hammering?

Does air in pipes act as in the air chamber of a high-pressure pump, until equilibrium of temperature is established between it and the steam?

Is steam formed under or above the surface of the water?

How, and by what means, is a very rapid production of a large volume of steam produced after a violent and destructive boiler explosion?

JOHN W. PAYLER.

Detroit, Mich.

Piston Rings

Piston rings cut on an angle are not generally found in a new engine, but rings made at a local repair shop are

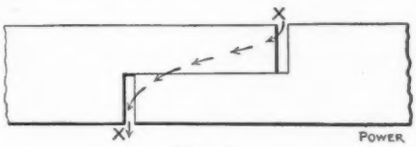


FIG. 1

usually cut in this way. Most engineers prefer the lap-cut ring.

By referring to Fig. 1 it is easy to see that after this ring wears any perceptible amount the joint is broken still more

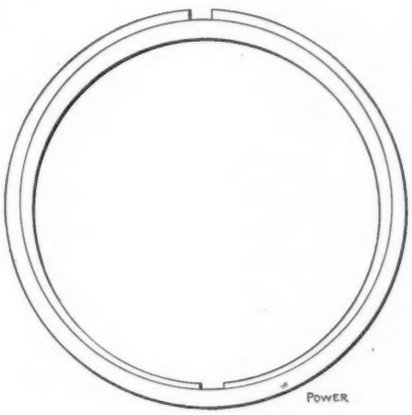


FIG. 2

at the joints $X X$ and that steam will enter at X on one side, as indicated by arrow and, going under the lap, makes its exit at X on the opposite side. The advantage of this kind of a joint over the

FIG. 3

diagonal joint is that the path of escaping steam is not so direct in the latter as in the former.

In order to remedy this leakage in the lap-cut ring, it would be necessary to put a false ring inside with its cut at the opposite side to the cut in the outside ring, or a short cover with a curved surface and tensioned, so as to bear against the underside of the joint to make it steam tight, as shown in Fig. 2. I prefer a whole inside ring as it takes care of itself better than a cover piece would.

The leakage of the angle cut cannot be remedied in any way. Fig. 3 shows the angle-cut ring joint open. Some engine builders use a single, sectional, lap cut under the covered ring, as suggested for a single cut ring.

LLOYD V. BEETS.

Nashville, Tenn.

Unexpected Happenings in the Steam Plant

One is so accustomed to having certain effects follow certain causes that, when the unexpected happens, a search for a reason or theory to explain it is begun.

In connection with a system of forced draft with which our boilers are equipped, there is a 10-foot piece of 4-inch pipe, capped on each end, the caps being tapped for ¼-inch pipe connections. This pipe is fastened to the wall of the boiler room in a vertical position, and steam at boiler pressure enters at the top and is condensed for supplying pure water to operate the blower-regulating valves.

In order to do some repairs, I blew out the water and sediment from the pipe mentioned and disconnected a ¼-inch union at the top, but being annoyed by hot vapor I stuck the nozzle of a hose into the hole and turned on the water, expecting it to condense the vapor inside the pipe and create a vacuum. Contrary to expectations, steam was generated in the pipe, which blew out the nozzle of the hose, and steam continued to come with much force and noise for about ten seconds.

All of our furnace-blower pipes take steam from the dome and come down at the front of the boilers, passing through the brick setting of the firebox to the blower jets at the back of the boilers, thence to the ashpit, thus superheating the steam which supplies the forced draft. That portion of extra-heavy iron pipe immediately over the fire was probably heated nearly red hot during the noon hour, and when the valve, which was a new one, was opened at 1 o'clock, the water of condensation which had accumulated above the valve was suddenly let into this hot pipe, and, flushing into steam, broke an elbow, notwithstanding that the jets were open.

Many years ago I ran an engine and boiler in a planing mill, firing with shavings, and sawing logs with dull saws and heavy planing sometimes made me work in trying to keep up the steam pressure. At that time I recommended a surface blowoff pipe, but the manager thought that his homemade boiler compound was just the thing. It was brewed in the boiler room and con-

tained soda ash, glucose and extract of logwood. These were all boiled in a barrel of water and when the density got beyond a certain point, the concoction would not stop boiling even with the steam shut off, but would go all over the floor.

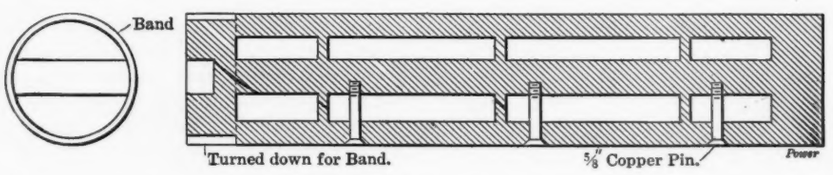
One day, when firing hard, the compound and mud suddenly got busy inside the boiler, and water and mud choking the engine caused the whole shop to tremble. Then the safety-valve lever flew up, and the valve did not stop blowing until half the contents of the boiler were on the roof, the sight of which convinced everybody that a surface blow-off was needed.

CHARLES HAEUSSER.

Albany, N. Y.

Repaired Corliss Exhaust Valve

The accompanying sketch shows a sectional view of a double-ported exhaust valve of a 26x48-inch Corliss engine and how it was repaired. The valve cracked all the way through and nearly across, as shown. This was due to either an excessive flooding of water or the valve being allowed to run with an insufficient amount of oil.



SECTIONAL VIEW OF VALVE

The valve was quickly repaired in the following manner: The exhaust-valve bracket was taken down and the steam head measured, leaving enough play on either side of the valve to allow it to be turned down for a ⅜x3-inch band, which was shrunk on. The valve was bored, countersunk and tapped for copper pins, and turned off to conform with the curvature of the valve.

J. W. DICKSON.

Memphis, Tenn.

Piston Ring Gave Trouble

Some time ago a 26½ and 50 by 33 vertical cross-compound engine was installed and considerable annoyance was experienced, due to the low-pressure piston ring clicking.

The ring originally sent with the engine was made up of six sections and reinforced or held into position by twelve spiral springs, equally spaced.

After many close examinations a new solid ring was sent for, which proved a success.

The sectional ring had ¼-inch clearance between each section, and steam getting into the clearance next to the ports caused a shifting of these sections, which produced a sharp clicking noise, just as the crank passed over the centers, or at the point of steam admission.

FRANK W. BELLINGER.

St. Paul, Minn.

Burning Lignite

I have two horizontal return-tubular boilers set in common brick setting. The boilers are hand fired and the coal used is North Dakota lignite which contains: ashes, 2.47 per cent.; clinkers, 4.23 per cent.; moisture, 39.76 per cent., and 6029 B.t.u. per pound. The factor of evaporation is 1.06, and upon running an evaporation test I found the evaporation to be four pounds of water to one pound of coal and the efficiency 68 per cent.

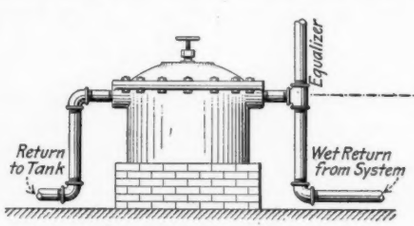
I would like to hear from POWER readers as to what they think of the economy of this boiler plant and if it could be improved in any way.

O. N. BERGMAN.

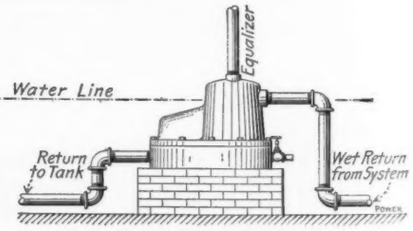
Dickinson, N. D.

Preventing Water Hammer at Trap Discharge

Recently a heating system was remodeled and the traps raised about 3 feet from the floor, and an equalizer pipe was connected from the joint where the return pipe entered the trap up to the steam main and the discharge changed from the sewer to the return line running to the power house, thus saving the water.



OLD ARRANGEMENT



NEW ARRANGEMENT

As soon as the new layout was put in operation, however, there was a complaint about the rattle made by the water every time the trap discharged, due to the cool water from the wet return meeting and condensing the steam in the equalizer pipe.

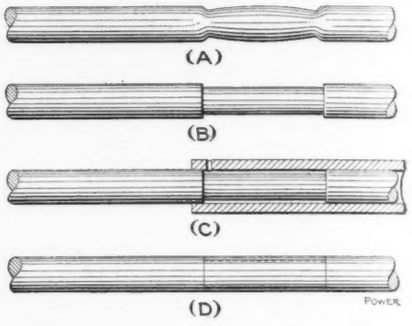
After trying several schemes, the trouble was solved in the manner shown in the accompanying illustration. The system is now operating noiselessly, as the steam comes only in contact with the surface of the water, heating it but slightly, and the discharge is constant.

W. T. MEINZER.

Brooklyn, N. Y.

Repaired Centrifugal Pump Shaft

A great deal of trouble is experienced with worn and grooved shafts which run in packing boxes, as in rotary, centrifugal pumps, etc., and this is especially true of shafts running at high speed, or when running under such high pressure that the packing has to be kept very tight.



SHOWING STAGES OF PUMP-SHAFT REPAIR

After a shaft has run for some time in a tight stuffing box in which hard packing is used, the shaft generally becomes badly worn and the expense of taking it out and replacing with a new one may be saved.

In one instance the shaft became badly worn, as shown at *A* in the accompanying illustration. It was taken out and filed down, as shown at *B*. A tube was then procured of the right size to be slipped over the shaft, as shown at *C*. A hole was bored in the tube, and babbitt poured in, thus filling the recess in the shaft, as shown at *D*.

The tube casing was then removed, and the babbitt finished smooth with emery cloth; the shaft was then ready for use.

If the shaft to be repaired operates under a very high pressure, it is well to sweat it with solder before pouring the babbitt, so that there will be no possibility of a leak starting between the shaft and the babbitt.

R. L. RAYBURN.

Kansas City, Mo.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

License Laws

The mere passing of a license law will accomplish nothing for, as has been shown by F. E. Albrecht, in the December 6 issue, the value of such a law may be entirely destroyed and, in fact, a state of danger may be created by its improper administration. Evidently, before the existence of the license law in the locality discussed by Mr. Albrecht, the plant owners were previously inclined to exercise some care in their choice of the men they placed in charge of their power plants; but since then these owners have naturally taken the path of least resistance and have accepted without further question the licenses issued by the examiners. Thus, the responsibility has been shifted to the examiners. If they meet it fairly then the results will be good; but if the examinations are farcial, the conditions resulting will be worse than those which existed without a license law.

On account of the good results that have been obtained within the jurisdiction of the Federal inspectors, A. A. Blanchard in the January 10 issue suggests that a Federal law bringing all engineers under its jurisdiction would be the best solution of the problem. It is possible that if a Federal license law for all engineers were placed in operation, the results might be all that he desires. Certain it is that such a law cannot be constitutional.

It must be remembered that the United States is a combination of States, once independent, who by adopting the Constitution have delegated to a central authority only those powers in which their interests were identical, retaining all others to themselves. The powers thus delegated to the Federal Government are limited and even though the Supreme Court has generally been very liberal in interpreting the Constitution as applying to laws passed by Congress, there does not seem to be any method of securing a Federal law applicable to all engineers.

Federal jurisdiction over steamboat engineers and that proposed for locomotive engineers is secured through the article in the Constitution which delegates to Congress the power "To regulate commerce with foreign nations, and among the several States, and with the Indian tribes."

License laws, whether Federal, State or municipal, will not in themselves cure the evils from which the engineer is suffering; but they may be the source of some trouble and vexation to him.

The ultimate interests of the engineer can probably best be served by following the path that POWER has been advocating for years; that of the education of the engineer in the safe and economical production and distribution of power, and the education of the plant manager in the knowledge that an efficient engineer in the power house is a safe investment and a large dividend payer.

GUY WISE.

Philadelphia, Penn.

CO_2 Recorder and the Operating Engineer

Of all the interesting and instructive articles that have appeared in POWER recently regarding CO_2 recorders, there is probably as much value to the operating engineer of small plants in the non-technical article recently contributed by our old-time friend, O. C. Woolson, and published in the issue of January 24, as in any of the very technical articles contributed by our "high-brow" brethren who tell us how much they know rather than tell us how to get results.

While I concede the value of the CO_2 recorder in the hands of a man who can apply the information which it enables him to get, such men are rarely found in the engine rooms of moderate-sized power plants and as it is quite probable that a large percentage of the readers of POWER and kindred publications are of this class, articles of the nature of Mr. Woolson's which they can digest and assimilate are of more value to them than the more technical articles.

I am led to express myself in this way by an occurrence of this morning. An apparent stranger stopped me and expressed his appreciation of an article that recently appeared in POWER on smoke prevention, yet he asked me the meaning of the term CO_2 which was used therein. I learned that this man was "firing" at the factory where the first test of the smoke preventer mentioned in the article was made some thirty years ago. Later on he secured an engineer's license and he has operated moderate-sized plants for the past twenty years or more.

This man is middle aged, perfectly satisfied with his present position and condition, has saved some money and owns his own home. He is sober, steady and reliable, just big enough for the job and the job is just big enough for him. There seems to be no incentive for him to climb. He is interested in reading of the experiences of other engineers of his class and I believe that there are thousands like him. I hope occasionally to contribute leaves from my own experience of over forty years in the belief that they will be interesting and beneficial to the men of this class. I believe that many a fact told in the form which Mr. Woolson used will stick, whereas if told in technical language they would make no impression.

But to return to the question of CO_2 recorders, I am quite sure that Mr. Woolson is in no way opposed to them. I take it that he looks upon them in the same way that I do upon the steam-engine indicator, a very valuable instrument for a special purpose in the hands of the true expert but a snare and a delusion in the hands of the novice.

I suggest that some simple and convenient method of weighing the coal and measuring the water be used. Then, with the quantities of coal and water to check against the output of the factory or mill, each week or month, the value of any change made in the engineer's department can be estimated in a more practical manner than by means of any tests of a few hours' duration that could be made by any of us so called experts, unless such tests are made for a special purpose.

If the man in the engine room has the ordinary good sense and a sufficient experience to keep the boiler settings in a good state of repair; the steam-generating surfaces clean from both scale and soot, the fires neither too thick nor too thin; see to it that both piston and valves are tight without undue friction and the valves properly set and that all of what might be waste heat is utilized for some useful purpose, he need have no fear of what CO_2 recorders and steam-engine indicators may show, if he uses his ability.

W. H. ODELL.

Yonkers, N. Y.

Flywheel Explosions

I have just read the editorial in the January 31 number under the above caption. With reference to the matter of flywheel inspection, I want to say that while an engineer and a piece of waste properly applied to the flywheel of an engine may not be an ideal combination, so far as apparently dignifying the engineer's position is concerned, it is otherwise an excellent one. I have contracts that do not mention work, only supervision, but I very often go over the flywheels and with a piece of waste in my hand make a close inspection of them. In this way faults may be discovered that would not be in any other way. There are too many men engaged in engineering work who are afraid of losing their "dignity" for the good of the profession, or humanity. I do not mean by this that the number is relatively great, but that even a very few are just so many too much.

There is nothing so assuring as to know that you have seen with your own eyes that everything is all right. If you depend upon others there are a good many ways in which you may be ill at ease. The other man may be deficient in knowledge, he might have been careless or negligent and, after all, you feel that you do not really know. If you look after such things yourself, you can feel that you do know, and that affords more satisfaction than the maintenance of any imaginary dignity.

Referring to governor troubles and inspection, I think the editorial "hit the spot" exactly. I recently went into a plant where an ammonia compressor was driven by a Corliss engine. This engine raced badly, and had been behaving erratically for a year or more. Within that year there had been a change of engineers. I started the engine and, true to its reputation, it started off like an impatient race horse. Had I opened the throttle wide, I do not know what would have happened. Although I opened the valve very slowly, the governor got hold of the engine even more slowly. I was suspicious at once from the sluggishness of the governor's action that the trouble lay there, and having had experiences of the same kind before, I went to the governor gag, or dashpot, and found it full of a mixture having a consistency between that of heavy cylinder oil and "taffy." With the bypass wide open it was almost impossible to move the plunger in the pot or cylinder. The only thing to do was to remove the heavy fluid from the dashpot and fill it with a light engine oil. After doing this the action was still too slow, and a part of the engine oil was removed and replaced with kerosene. After this, one could hardly cause racing had he wished so to do, the governor controlled the engine so well.

There can be no question as to the value of many automatic devices, but I can never get rid of the belief that a man with a watchful pair of eyes and an active mind behind them is one of the best safety devices ever invented.

The tendency of some men to overlook small things that give trouble, while looking for something great, deep and mysterious, is hard to understand. There are engineers who can talk engineering Latin and Greek so fluently as to make one feel real small, and yet when you get a chance to pry into their work, you often find such conditions as I have described. On the other hand, you will find some engineers who have so little to say that you are led to wonder how they happened to escape the "cows" so long, and yet when you get an opportunity to go over their work you find ample evidence that they have been more busy with their brains and hands than with their tongues.

WILLIAM WESTERFIELD.

Concordia, Kan.

The Engineer's Wage Problem

I was glad to see that Mr. Morton got his raise in pay (see the issue of January 17). If he had not, I would have half suspected that he was not worth what he was getting to begin with.

Seriously, too many of us compare ourselves with the wrong man. Values are all comparative. Mr. Morton's predecessor was evidently worth a number of dollars a day less than nothing. If he had been worth what he was getting, Mr. Morton would not have been able to get the job. Having gotten the job, it was up to him to give his employer his money's worth of service. To have saved $2 a day would not have entitled him to anything but discharge.

The engine and boiler were adequate in size—Mr. Morton admits it. His employer evidently knew it and would have fired one engineer as quick as another until he found a man who could produce results. If he could have found a man who was able and willing to get results and who was willing to work for 25 cents per day less than Mr. Morton, he would have been glad to do so. Evidently, this particular employer had his mind made up to save about $11 per day by paying $1.75 for the service. If Mr. Morton had saved $15 a day, very likely his employer would have thought twice before he gave him a raise as small as 25 cents.

Here we come to another question. How much did Mr. Morton ask for? Eleven chances out of ten he did not go to the boss and lay out the proposition on paper and prove to him how much he deserved. Probably, it took him a week to screw up his courage to ask if he could have more money. The boss saw that he was afraid to call his soul his own and raised him a "quarter" because it salved his conscience and did not cost much.

It must be conceded that an operating engineer drawing less than $3 a day and with no money in the bank is in little better than a state of slavery, particularly if he has a family dependent upon him. Statistics show that in New England the average family is only two weeks from starvation. A man who asks for more pay cannot usually prove that there is no one more competent who will take the place for the same money. The employer is apt to assume that there is such a man available at least until the present incumbent packs up his kit to go. By that time, if both sides are bluffing, they both are so mad that they have no further use for each other.

They both suffer. The engineer, by loafing until he hits another job at a few cents a day less than he was receiving before and a promise of a raise of 10 cents a day if he saves $10. The employer, by losing $100 a day from his product at a loss to himself of the profit on that amount. The difference is that the employer is usually better able to stand the loss than the worker. Consequently, he has the upper hand.

I wonder if it has ever occurred to other readers that this country's prosperity is absolutely at the mercy of wage earners.

There is, somewhere, about $36 in actual money in circulation for every man, woman and child in the land. Assuming that one person in ten is a wage earner, which is on the safe side, this would be $360 for each wage earner, or approximately 30 weeks' wages for each one. If every wage earner should suddenly decide not to spend any money for 30 weeks and to put it all in the old teapot or hoard it away anywhere, immediately a money stringency would begin and in less than two months these wage earners would have the whole country at their mercy. Of course, the fact that the average family is only two weeks ahead of the game precludes the possibility of this thing being done. Also, men who are in any way thrifty do not hoard away money. They deposit it in banks and the banks put it in circulation again.

The moral of all this is that a bank account large enough to live on for two or three months is worth all the sacrifice it costs. It is all very well to own a house, but it has the drawback of not being edible. The "long green" can be relied on for sustenance at any time or place short of a desert island. The man with a very modest bale of it in cold storage can go to the boss and treat him like an equal when he says, "I am earning more money than I am getting. You cannot get a man to fill my place that will really fill it as I do. I have not bothered to look up another job, because I know you cannot afford to lose me."

That puts the thing on a business basis where it is up to the boss to show cause why the aforesaid service that has been rendered is not worth the money demanded.

After all, why should not the man with something to sell put a price on it? A few years ago the purchase of a pair of boots was a matter of artistic haggling or bargaining. Today, we fight shy of a shoe store where the prices are not marked in plain figures. I am inclined to believe the working people are practically being sold at auction all the time and only for the lack of a supply of money to carry them over a few days of idleness. If a shoe dealer has to raise money he does not sell his shoes at auction, except as a last resort. In the first place, he does not buy shoes up to his last dollar. He saves a little money to do business with. If that is exhausted he borrows, but he does not cut the price of the shoes to raise money. You may think he does by reading his advertisements, but you can safely bet that he marked them up the day before.

Now, a wage earner ought to take example from this. Having set his price he ought to stick to it. In fact, he has no right to come to me and ask me $2.50 a day and then go over to Jones across the street and go to work for $2.25, because Jones scares him into it. He ought to treat us all alike.

E. F. HENRY.

Worcester, Mass.

Handling Men

The discussion in several of the late copies of POWER relative to the chief engineer having "pets" about the plant has been read with interest by the writer. During my experience I have failed to find a chief who was not accused of having pets, especially if he has a number of men under him.

The crew of men never existed that did not have some members who were more ambitious and studious than others. These men the average chief will aid in any way he can; consequently they become more friendly and intimately acquainted. Other members of the same crew do not take as much interest or perhaps think they are too well posted to consult with the chief. Eventually they will become "sore-heads" and think the chief is showing partiality.

Regarding the equal division of work among the men, I think that nine times out of ten the so called pet is willing to do more than his share. The writer does not uphold any tale bearing; on the contrary, it is better to dispense with the services of such men.

EARL E. WEBSTER.

Phœnix, Ariz.

Baseball Problem

Some things are just as clear as mud and that is the condition in which the baseball problem (December 20 and 27 issues), conceived by Prof. A. S. Reeves and elucidated into a state of opaqueness by Uncle Pegleg, now exists.

The high jinks which Professor Reeves, D. E. (Doctor of Entropy) can cause a simple—save the mark—molecule to perform when touched up by a little heat would scatter the brains of a Socrates. He has now invented a "manless something" to hold the stop watch on the earth as it goes round. What next?

But let's to the game and the problem. From the technical terms he uses it is evident that Professor Reeves is trying to qualify as a baseball expert. Uncle Pegleg who—to tell the truth and shame the devil—has more sense than legs, can hardly be expected to play ball, so we will make him umpire.

The pitcher takes his stand on the equator with the ball in his hand and faces east. Earth, pitcher, ball and everything else are going 300 feet each one-fifth second, but no energy is going into the ball. The pitcher now goes down in his "jeans" or his anatomy or some other place of concealment about his person and digs up 18 foot-pounds of energy. In one-fifth of a second, just as he whizzes by the manless something, he delivers the 18 foot-pounds to the ball. Behold! The ball now has 918 foot-pounds of energy more than it had before. Where did the 900 foot-pounds come from? They tell us that it is due to the earth having gone 300 feet in that one-fifth of a second. Well, has not the earth been going 300 feet each one-fifth second ever since we have been talking? It never succeeded in getting 1 foot-pound into that ball before—much less 900. The bug under the chip, and the nigger in the wood pile are not anything to this.

The pitcher picks up another ball and faces the west. Everything going 300 feet each one-fifth second, same as before. No energy going into or out of the ball. Down into the "jeans" again and 18 foot-pounds more of energy fished up. Round comes the manless something. Into the ball in one-fifth second goes the 18 foot-pounds. Speed of the ball now, 1440 feet per second. If the curious figure this out, they will find that the ball has lost 882 foot-pounds of energy.

Perhaps these scientific figurers will tell us that *this* was because the earth went 300 feet in *that* one-fifth second. Gain or loss, it is all the same to them. Same old explanation. If the earth was to stop moving it is hard to tell what these figurers would do.

Hold 'em off, Uncle Pegleg!

J. C. MORRIS.

New Orleans, La.

A Mechanical Engineer's Experience with the Cornell System

Natural laws, theory and engineering rules practically proved, demonstrated and accepted by the engineering world have been set aside and declared all wrong and worthless by a modern prodigy from the staid city of Philadelphia, who has convinced some erstwhile conservative business men and mechanics that he has invented and perfected an apparatus which when applied to a boiler at $10 per horsepower will save from 42 to 60 per cent. of the coal used.

Why it will not save 60 per cent. all of the time has not been explained.

Results of tests made by a convert to this wonderful *system* show a commercial evaporation per pound of combustible on March 10, 1909, of 11.27 pounds and on March 11, 1909, of 11.28 pounds before fitting the boiler with the *system*.

The same boiler equipped with the *system* produced on March 23, 1909, an evaporation of 15.03 pounds; on March 25, 1909, 16.69 pounds; on March 26, 1909, 18.01 pounds, and on February 10, 1910, 16.14 pounds, a variation of 20 per cent. in the efficiency of the *system* and a saving of from 42 to 60 per cent. over the original equipment.

A test which I made on the same boiler equipped with the same *system*, fired by the same fireman, on April 28, 1909, showed a commercial evaporation of 10.69 pounds per pound of combustible.

The inventor kindly informed me that the reason for my failure to obtain a higher evaporation was that I followed the rules recommended by the American Society of Mechanical Engineers, which is not the correct way to test boilers and that anyone who could not obtain the same results with his *system* as his convert had, was not a capable testing engineer.

He also informed me that computations which I made, showing the impossibility of creating heat available for commercial use, by decomposing steam and burning the resulting gases as he claims to do with his *system*, were not correct, but as he could not point out wherein they were wrong, he would have his consulting engineer analyze the figures and advise me regarding same.

He has had my figures several months now, but I have never had the advice promised.

A partial analysis of the results of one test published for advertising purposes presents claims as follows:

Test of March 26, 1909, using fuel having an actual heat value as determined by chemical analysis, of 14,407 B.t.u. per pound.

B.t.u. necessary to evaporate 18.01 pounds water	17,392
B.t.u. necessary for loss due to radiation, to flue gas, moisture in coal and all other causes	5,217
B.t.u. total necessary to obtain results claimed	22,607
B.t.u. necessary to create from steam	8,202

From the foregoing it will be seen that to obtain the results claimed it would be necessary to create heat from steam, available for the evaporation of water, to an amount equal to 56 per cent. of the total amount of the heat contained in the coal used.

GEORGE P. GILMORE.

Fall River, Mass.

Automatic Nonreturn Valves

The remarks by E. H. Lane in the January 24 issue regarding nonreturn valves are worthy of note for at least two very good reasons.

In the first place, equipment of this kind in the boiler room makes for the greater safety of the employees; and, secondly, it often obviates the necessity of shutting down the whole boiler plant should one or more tubes blow out in a boiler. The instances which he cites are not the only ones in which valves of this kind have amply justified their installation, for I have heard of a number of others and know personally of one case where a tube was blown out and the nonreturn valve operated instantly, thus cutting out that particular boiler.

A nonreturn valve operates, however, only when there is a break or sudden drop in pressure on only one side of it. While it is perhaps more common to have a tube blown out than to have a break in the header or on the other side of the valve, such things have been known to occur. In a case of this kind a simple nonreturn valve would, of course, be useless.

I recommend, therefore, that a step further be taken in the adoption of a triple-duty valve. With a valve of this kind it would make no difference on which side a break occurred as it would close immediately and thereby cut out the boiler. The reader is, no doubt, familiar with this type of valve; it will operate no matter on which side the break and consequent pressure drop occur, and, in addition, it can be closed by means of a handwheel and stem just like an ordinary stop valve. That is why it is called a triple-duty valve.

In addition to such a valve, it is a good plan to have an ordinary stop valve —perhaps preferably a gate valve—located between the former and the header with a drip cock in the pipe between the two valves so that anyone going into the boiler will be absolutely safe from scalding, due to a leaky valve.

This would be appreciated very much by the boiler inspector. The drip cock, of course, is only intended to prevent any building up of steam pressure between the two valves, should the stop valve leak.

In conclusion, I wish to say that I am heartily in accord with Mr. Lane in wishing to see such installations made compulsory, for the safety of the workmen should be of paramount importance in every boiler plant.

EVERARD BROWN.

Pittsburg, Penn.

Boiler Inspection Laws

The Pittsfield explosion awoke some to the realization that the lap-seam danger is not the only one that confronts us here in Massachusetts. On the other hand, there were those who were not in the least surprised. They may not have been "telling you so"; but they have been expecting it. And, if a few more explosions should happen tomorrow, it would not cause them much wonder. Massachusetts has been getting too smugly complacent. Because it has the best laws of any State in the country, its people have been strutting around with pride, when they should have been treading with circumspection. We have been looking at the disasters abroad and have overlooked the dangers at home. Because we have the best laws is no reason why they cannot be improved; and laws are not sufficient—there must be rigid enforcement. There are too many dangers that yet threaten.

"Agricultural" boilers are outside the law, though one finds no reason for this exemption. An old lap-joint boiler condemned for factory work, may be sold to a florist and set up in a greenhouse within ten feet of a busy highway, and any pressure to suit the ignoramus of a greenhouse man may be put upon it. A road-roller boiler must be inspected and must be under the care of a licensed engineer; but a threshing-machine boiler need have neither. Bring the farmer into line. He needs safety as much as the shop worker.

Not long ago I entered the engine room of a factory and about the first thing that I noticed was that the engine was slowing down. The speed came down almost to a stop, then speeded up again. Upon investigation I learned that the governor was out of commission and that the engine was running with the throttle "set" for the ordinary load. It would have cost possibly $5 to repair the governor and the increased production of the machinery would shortly have paid the bill; but the boss would not see it. The owner holds a license to "cover" the plant and hires a fireman to do the work. One does not enjoy picturing what might happen to that flywheel if several big machines should let go at once when the fireman happened to be out. The treatment that the boiler gets may be imagined from the fact that one day when the waterwheel gave trouble they got up steam from cold water in 45 minutes.

Another "engineer" in another town boasted to the writer of having done the trick in 35 minutes.

In another case, a power plant had been shut down during the winter and was about to be started again. A slow fire was put under the boilers, but as no pressure showed on the gages it was in due time increased and later urged to a good, hot fire. Then, suddenly, the safety valves opened. The gage pointers were still anchored. The engineer claimed that an enemy of his had loosened the gage hands and put them back of the pin. Perhaps that was so, but no real engineer will ever be caught in that way. What if this "enemy" had also seen fit to screw down on the safety valves?

In another plant the engineer frequently leaves his boiler and engine running and goes uptown on a shopping trip or over home for a lunch. I was once requested by my employer to go on an errand to a neighboring factory. This would have left the engine and boiler without an attendant. At another time a request came down to "help clean up the cellar." Of course, I did not do either, but the incidents are cited to show how ignorant some factory owners are of the engineer's duties. There are many engineers who are doing such things nearly every day. Happily, the inspection department is waking up to this danger and is taking steps to abate it. Let us hope they keep at it. The employers need enlightenment and the engineers need starch.

In another case a crack was found in a cast-iron flange of a 12-inch steam header. The chief engineer proposed to cover the thing up again and let it go. He had an assistant, however, who would not stand for such tactics, and the flange had to be replaced. When men will take such chances to save a few cents and make a record, why wonder that accidents happen?

A few days ago in a plant not far from Boston, the safety valve stuck and the pressure ran up far beyond the blowing point. The engineer was in a distant part of the factory. The fireman ran. The superintendent, one of the know-it-all-butt-in type, mounted the boiler and lifted the valve. Luck was on his side; there was no explosion. It was just one more of those many narrow escapes that we all know about. It might be urged that those engineers who know of these things should report them to the State inspectors, and it may be said that they sometimes do. But, too often there are leaks in the office. The "strictly confidential" report is so treated that the guilty party learns the name of the person who made it. Corporations can cause a man considerable inconvenience and expense if they wish, and a man often hesitates to report things against them for fear his name will be turned over to them. This is not right. A man should be able to report dangers without running personal risk.

Here are a few hints of lines along

which progress is possible. Let us quit boasting and do something to boast about. Let us "look forward, not back."

WILLIAM E. DIXON.

Malden, Mass.

Setting Us Straight

C. H. Parson, in the issue of February 7, says that the use of a steam jet under the grates prevents clinker, but says also that his experiments, "absolutely disprove the statement * * * that the temperature of the fire must be reduced in order to prevent the formation of clinker." He gives no reason, however, why the steam prevents clinker, or in what other way it can act, if it does not reduce the temperature. If steam does prevent clinker, there must be a reason.

As a matter of fact, steam does reduce the temperature of the fire to some extent, even if the steam is not decomposed. A formula for the theoretical temperature of the fire is given on page 786 of the eighth edition of my Mechanical Engineers' Pocketbook, as follows:

$$T = \frac{616C + 2200H - 327O - 44W}{f + 0.02W + 0.18H}$$

where, T equals temperature of fire above temperature of the atmosphere and C, H, O and W, respectively, the percentages of carbon, hydrogen, oxygen and moisture in the fuel; f equals pounds of dry gases of combustion per pound of fuel. When steam is delivered with the air under the grate bars, it is practically equivalent to moisture in the coal as far as its effect on the temperature of the fire is concerned. Assuming a dry fuel containing in the combustible portion 0.90 C, 0.05 H and 0.05 O, the formula gives an elevation of temperature of 3107 degrees Fahrenheit; but if 10 per cent. of water is added, making the analysis 0.81 C, 0.045 O and 0.10 water, the temperature elevation is only 2710 degrees, or about 13 per cent. less. Even if allowance is made for the heat carried in by the steam, about 100 B.t.u. for 0.1 pound of steam, the temperature would not be raised 100 degrees.

A greater cooling takes place, however, at the bottom of the fire, close to the grate bars, if any of the steam is decomposed into oxygen and hydrogen. The dry coal used in the illustration has a heat value of 15,800 B.t.u. per pound of combustible. The hydrogen in 0.1 pound of steam is 0.0111 pound; the unburning of which absorbs

$$0.0111 \times 62{,}000 = 689 \text{ } B.t.u.,$$

or over 4 per cent. of the heat value of the fuel.

That it is possible to decompose steam when it is mixed with, say, 20 times its weight of air, by blowing the mixture into white-hot carbon, I do not think has been satisfactorily shown by experiment. If carbon at a very high temperature has a greater affinity for hydrogen than it has for the oxygen in the air, it may decompose the steam and form water gas,

$$CO + H,$$

which will burn to $CO_2 + H_2O$, reforming the same amount of steam just as quickly as the gases CO and H become mixed with enough oxygen from the air, and generating again the heat that was absorbed in the decomposition. If it takes some appreciable time for the sequence of reaction to take place, then there may be a cooling of the fire by the decomposition of the steam immediately above the grate bars, and a recomposition higher up in the fuel bed or above it. This possible action was pointed out many years ago by Dr. R. W. Raymond, in the *Transactions* of the American Institute of Mining Engineers.

WILLIAM KENT.

Montclair, N. J.

Somewhere, someone has written something about consistency being a jewel.

In the February 7 issue, under the above heading, Mr. Parson makes a number of the most inconsistent statements that could well be imagined.

He first objects to a suggestion that the flue doors be opened to check the draft through a horizontal return-tubular boiler when it is banked, on the score that doing this would cause cold air to be drawn through the tubes. Anyone who knows the difference between a horizontal return-tubular boiler and a cross-compound steam engine, must know that there is no more certain way of preventing cold air being drawn through the tubes when banking the fire than by closing off everything else and opening the flue doors.

Mr. Parson suggests that the flue doors be left closed and a part of the grate bare; this would certainly be about the best way to pull cold air through the tubes, and could only be exceeded in this respect by opening the fire doors. He also objects to opening the flue doors at night because this will cause them to leak during the day; he certainly must have gained his experience with flue doors constructed along very peculiar lines.

His principal objection to the leaky flue door is that it is a great detriment to the economical production of steam, where natural draft is used. The only result that can be produced by a leaky flue door is an impairment of the draft, and if there were sufficient draft, notwithstanding such leaks, there could be no practical effect on the efficiency.

The second grievance of Mr. Parson is in regard to the use of steam under the grates. In the third column of his article he shows his inability to remain consistent by objecting strenuously to the editor's statement that steam admitted below the grates reduces the temperature of the fire and then immediately admitting that he tested with a pyrometer and found that steam does reduce the temperature. A little further on he states that the steam does not materially reduce the temperature of the fire but in many cases improves it. It is difficult to tell what Mr. Parson really believes about this matter; but it appears that what he wants is to make himself and others believe something which experience indicates is not correct. Steam admitted under the grate is one of the most effective and most used methods of preventing clinkers.

It would seem that Mr. Parson should at least have struck it right in one out of his three criticisms, but the third one is apparently as far off as the first two. To show just what was stated, the question and answer will be repeated.

"What is the correct number of square feet of heating surface to be reckoned for a horsepower in different types of boilers?"

Answer: "Ten square feet of heating surface per horsepower has always been the standard used by the makers of water-tube boilers; and from 12 to 15 the standard of the makers of other types. But recently the opinion has prevailed that the heating surface in other types is as efficient as that in the water-tube, and 10 square feet of heating surface per horsepower is now the rating for all types of boilers."

Mr. Parson objects to the rating given for a horizontal return-tubular boiler on a basis of 10 square feet of heating surface per horsepower because the inquirer was talking about a boiler which was already built and states that it should not be rated like one that was being made at the present time.

If there is any valid reason why horizontal return-tubular boilers of the same size and number of tubes built during the spring of 1905 and the fall of 1910 should be rated on different bases, the engineering fraternity would doubtless be under lasting obligations to Mr. Parson for an explanation of the reasons. The New England boiler manufacturers adopted a basis of 10 square feet of heating surface per horsepower for rating horizontal return-tubular boilers about 1907 and there is no reason why it is not perfectly proper.

J. L. JONES.

New Haven, Conn.

The Parliamentary Commission, which was appointed some time ago to consider the expediency of holding a universal exposition in Paris in 1920, has presented a report to the Government in favor of this project. The proposed date of the exposition will coincide with the termination of the extensive program of works for embellishing Paris.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

A Catch Question

A boiler has been made using tool-steel rivets with extra large heads so that they will not pull through and it is not possible for them to shear. The plate must fail by crushing in front of the rivets. If, after this boiler had been tested it was found that the metal in front of two of the rivets had disappeared, what became of it?

T. T. P.

Boiler rivets are made of soft steel or iron and never, even for a test, of tool steel, and the question is one to discover how much is known of the character of the materials used in boiler construction. The reference to the supposed disappearance of a part of the sheet is inserted to draw the attention from the main question, which, put in plain English, would be: Of what material are boiler rivets made?

Stress on Boiler Stays

Figure the stress between the stays and give proper pitch of 1-inch stays, 54,000 tensile strength for a working pressure of 155 pounds.

S. B. S.

Staybolts 1¼ inches diameter or less are allowed 6500 pounds per "net section." The area of a 1-inch staybolt having V threads 12 to the inch is 0.575 inch

$$6500 \times 0.575 = 3738 \textit{ pounds}$$

allowable stress on one bolt. For 155 pounds pressure

$$3738 \div 155 = 24.24 \textit{ inches}$$

of surface to be supported by the bolt. To find the pitch extract the square root which gives 4.923 inches pitch. In this the area of one staybolt hole has not been deducted.

In close calculations the area of the hole may be deducted, but Massachusetts rules do not require this. In practice the pitch woud be either 4⅞ or $4\frac{15}{16}$ inches. As the stress on the plate would be supported by the stays, it would not enter into the calculation.

The plate for 155 pounds pressure and above pitch should not be less than ⅜ inch thick, whether flat or circular furnace.

Weight of Castings

How can I estimate the weight of iron and brass castings?

I. B. C.

An approximation may be made by weighing the patterns and multiplying the weight by 19 for brass and by 17 for iron if the patterns are made of pine.

Equalizing Piston Clearance

How is the piston clearance in an engine cylinder equalized?

E. P. C.

By disconnecting the connecting rod and pushing the piston to one end of the cylinder until it strikes the head; make a mark on the guide at one end of the crosshead and then move the piston to the other end of the cylinder and mark the guide as before. Lengthen or shorten the distance between the connecting-rod brasses until the crosshead travels equally between the marks on the guide.

When the piston rod screws into the crosshead, the total clearance may be found, and with the crank on the back center the piston rod may be screwed in or out until it is equal at both ends.

Inspection of Boiler Plates

Suppose the owner of a power plant came to an engineer and said in regard to a new boiler that had been ordered, "I have been talking to the boilermaker about that boiler and he says he has some plates that are all right. I have told him that if you said the plates were all right he could build me the boiler." Now, what would the engineer look for? The plates are all right in regard to tensile strength and chemical tests and are rolled nice and smooth and free from blisters and so forth.

B. P. F.

If in Massachusetts, the engineer would look for nothing at all, as the boiler to be installed must comply with the requirements of the Board of Boiler Rules and any observation or investigation on the part of the engineer would be supererogatory. In any other State he should measure each plate with a micrometer at various points on the four edges to ascertain the exact thickness and reject all plates of less than the proper thickness; require mill-test affidavit of chemical and physical tests and check the heat number of each sheet.

Safety Valve Calculations

Please give in plain English without algebra or formulas the rules for calculating the pressure, length of lever, weight of ball, distance from fulcrum, etc., of lever safety valves.

L. S. V.

To find the pressure per square inch which will balance a valve with a given weight at a given distance from the fulcrum, the effective weight of the valve, valve stem and lever being known.

RULE: Multiply the weight by its distance from the fulcrum. Multiply the weight of the valve and the effective weight of the lever by the distance of the stem from the fulcrum, and add this to the former product. Divide the sum of the two products by the product of the area of the valve multiplied by its distance from the fulcrum, and the result will be the pressure in pounds.

To find the distance from the fulcrum at which the weight must be placed to balance a given pressure per square inch.

RULE: Multiply the area of the valve by the pressure, and from the product subtract the effective weight of the valve and lever. Multiply the remainder by the distance of stem from fulcrum, and divide by the weight of the ball. The quotient will be the required distance.

To find the effective weight of the lever, valve and valve stem.

RULE: Multiply the actual weight of the lever by the distance between its center of gravity and the fulcrum, and divide by the distance between the fulcrum and the stem. To the quotient add the actual weight of the valve and the stem.

Engine Running Under

What are the advantages, if any, of running an engine "under"?

R. U. E.

When an engine runs "over," the lower guide bears the weight of the crosshead, part of the weight of the connecting rod and one-half the weight of the piston rod in addition to the pressure due to the diagonal thrust of the connecting rod. When the engine runs "under," the diagonal thrust of the rod forces the crosshead against the upper guide with a pressure which is reduced by the weight of the crosshead and rods, which reduces the friction load of the engine.

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POWER

Graft

The practice of accepting considerations from salesmen of engineering supplies for influencing the purchase of their goods is belittling and corrupting to the man who does it.

Amos Skeg, whose communication upon this subject appears in POWER for February 14, is a good engineer and an upright man. We do not believe that he would buy or recommend the purchase of any machinery or supplies because the sale meant a commission to him, and we do not believe that, having recommended a thing because he thought it was the best and cheapest, he would demean himself by accepting a tip for which he had rendered no service.

The waiter, or porter, or barber has an excuse for the tip which is given him in supposedly special personal attention and extra service. The engineer has no justification for accepting gratuities for which he has rendered no service, even if he is willing to put himself into the tip-receiving class.

No amount of sophistry or argument will justify the practice and we deplore the aid and comfort which those who practice it will derive from Amos Skeg's communications.

It may be true that there is more temptation to find a justification for grafting on the part of a man who, as Mr. Skeg says, views the subject from the edge of a coal pile while cogitating on the dismal fact that the grocery bill will have to go over another week in order that the kiddie may have a new pair of shoes, than on the part of one who considers it from an office chair with the assurance of a comfortable income; but the fact that one needs the money is no justification for a practice otherwise questionable.

The fees and commissions of a professional engineer are not graft when he earns them. He may undertake to do the planning and oversee the installation of a plant for a fixed fee or for a commission or percentage of the cost. So long as this is the agreed method of payment and is abided by, there is no graft. But, if he abuses the power of recommendation and purchase with which the connection endows him by accepting commissions from the sellers of apparatus in addition to the fee or commission which he is accepting from the purchaser, he is a grafter, and he is just as much a grafter if he leads himself to think that his judgment is not influenced by the commission, or that the purchaser is paying no more than the market price and that the commission would stay in the "bulging pockets of the salesman" if he did not collect it.

When we mentioned the high ideals of the professional engineer, however, we had in mind the operating, not the consulting class. Society orators will harp upon the manifold attainments, the highly specialized knowledge, the weighty responsibilities, the executive ability which raise the man in responsible charge of the modern steam plant to the professional plane, and go behind the boiler the next day and sell themselves to an oil peddler for a two-dollar bill.

Two good tests to apply to a transaction are to ask if it will stand daylight, and what would happen if everybody did it. You, who are taking tips from your supplyman, would you be perfectly willing for everybody to know it? Do you let your employer know how much you get for dealing out his patronage? And, if he, trusting in you so absolutely that he believes these tips make not a bit of difference in the cost to him or the quantity or quality which he gets, is willing for you to accept them, do you make the salesman understand that the orders would come just as promptly and just as regularly whether you got the tip or not? Do you let your friends, who look upon you as a responsible salaried man, know that a part of your income is composed of gratuities from supplymen? If you earned an extra twenty-five dollars by indicating the engine of a neighboring factory or by testifying in court upon some mechanical question, you would be rather apt to talk about it. Is your reticence concerning your gratuities induced by an unadmitted sense of shame?

Mr. Skeg asks if the acceptance of the premiums offered for the securing of subscribers to POWER or the premiums offered by advertisers for the purchase of their goods or the acceptance of a consideration for writing an article, consigns him to the blacklist.

The premium for getting a new subscriber is legitimate pay for a legitimate service; so is the money which is paid for accepted articles. If you purchase goods with somebody else's money for the purpose of getting the premium for yourself, it is graft.

On the B.t.u. Basis

An old gentleman in a Western city had invested his savings in a power building and for years had lived comfortably upon the rents, given his girl a good education and sent his boy to the State university. Upon graduating, the boy set out to administer the property in accordance with the latest developments of the art. One of his first moves was to summon the coal man.

The latter knew what was coming, and had come prepared. "Now, look here," he said, "I know we sell you a lot of coal but we sell it to you right. Your father was one of our first customers and we've always looked out for him like a friend of the family. He gets the best there is and at a price that won't stand talking about out loud. Now, you just let the thing run along and don't go to stirring things up or you'll break up a deal that it will be hard to get back into."

"That's all right," returned the young fellow, "but we are going to run this thing on a business basis. We want to know what we're getting. What per cent. of moisture is there in this coal that you're giving us?"

"What's that —?"

"How much moisture does it contain? How much water is there in it?"

"Water! There ain't no water. It's good, dry coal—dry as a cracker."

"What per cent. of ash has it got?"

"Ashes? There ain't no ashes in it. It's good, clean coal I tell you; the prettiest there is mined."

"How many B.t.u.'s are there in it?"

"Not a d——d B.t.u."

Publicity of Operating Costs

In everyday life there is little which, if viewed abstractly, conveys much meaning, but when compared with some familiar object or incident its value and significance assume definite proportions. This is particularly true of engineering practice.

To one unfamiliar with the performance of steam engines the mere statement that a certain engine has a water rate of fourteen pounds conveys little information, although the definition of the term "water rate" may be thoroughly understood; but when it is known that this figure very closely approaches the best performance of engines of this type and size, its significance is at once apparent.

Similarly a person having access to no test data would fail to differentiate between a boiler efficiency of seventy-six per cent. and a generator efficiency of ninety-six per cent.; and, taking the higher figure as a standard, would class the performance of the boiler as poor, whereas it would be exceptionally good.

In engineering, theory and mathematics are useful, but they serve principally as a guide or check to empirical rules. The real foundations of engineering practice are based upon experience.

Developments along engineering lines are so rapid that the standards of practice are constantly changing; but, in order that widespread benefit may result, it is essential that everybody concerned shall contribute his own experiences, whether success or failure, to the common cause.

The managers of plants making exceptionally good records often refuse to give out any figures for fear that the public will think they are making too great a profit. On the other hand, many plants that are making a poor showing will not disclose any facts concerning their operations for fear of being criticized. Both are assuming an attitude tending to impede progress; the former by refusing to aid its neighbor, and the latter by practically refusing to accept aid.

Speak Up

Human nature is composed of a peculiar mixture. Many people have such an ingrained fear of being criticized or ridiculed by their fellows and associates that they are deterred from expressing their opinions no matter how sure they feel of being correct. To every question there are two or more sides, and in the words of Wendell Phillips, "He does not really believe his opinion who dares not give free scope to his opponent." Once, during a "dinner-pail" talk, a certain operating engineer's veracity was seriously questioned because he stated that the shaft of the De Laval turbine rotates at thirty thousand revolutions per minute. The expressions of disbelief were even more forcible when he stated that this was a moderate speed when compared with that used in grinding small holes.

The recanting of Galileo at the command of the Inquisitators did not stop the rotation of the earth upon its axis, but the fear of the derision of his fellows has deterred many a man from that development and progress which was within his grasp. It is an extremely fortunate thing that the great minds which now stand symbolized by certain human names did not bow their necks to the storm of derision expressed by their contemporaries.

As it is in the large and grand arena of a world entire, so it is within the circumscribed limits of the workshop. Success comes, not at the beck and call of one's fellows and associates, but at the demand of the mind of the individual who has the will to be responsible for himself. The man with a message to his fellows is, fortunately for the world, in most cases the one who is determined to deliver it. It is to be regretted, however, for their own sake as well as the world's, that many fail.

"Be sure you are right, then go ahead"—and let them howl!

American Institute of Boiler Inspectors

Among the many organizations born during recent years there are few which will be watched with keener interest by those engaged in the generation and transmission of power than the Institute of Boiler Inspectors.

When the responsibilities resting on the boiler inspector are considered, the value and the possibilities for the accomplishment of good by a society of this nature become apparent. On him devolves the duty of deciding the ability of a boiler to withstand the effects of the pressure of the confined steam which with the stored energy in the highly heated water is productive of such destruction when an explosion occurs. This demands on the part of the inspector a thorough knowledge in detail of all types of boilers, besides the technical training that is absolutely necessary to enable him to decide constantly arising questions of strength of materials, of methods of construction and operation.

With education along lines leading toward increasing and spreading the social and technical advantages resulting from coöperation as its keynote, the society is bound to succeed in placing itself in the front rank of beneficial organizations.

It would seem to be a simple matter to weigh the coal fed to a battery of boilers, and the water which they evaporate, and determine how much water is evaporated per pound of coal. There are a lot of ways that one can fool himself, however, in this apparently simple operation. Try it under similar conditions and see how careful you must be in order to get consistent results.

Officials of several boiler-insurance companies have told us recently that their losses from "safety" water-tube boilers exceed those from all other classes, even taking the number insured into account. The failures seldom attain to the importance of an explosion, and usually escape notice in the press, but the aggregation of losses from tube rupture is becoming serious.

Have you had any trouble with boiler tubes? If so, how do they fail? Do they open in the weld, thin out and burst, or do pieces drop out of them?

If all of the little things about a plant are given "first aid" when needed, there will be no large one to add to life's burden.

Usually a man's reputation is good until he gets into trouble. Bluff does not count for much when an emergency arises.

Congratulations to San Francisco. Now show them what a real exposition is like.

A New Boiler Feed Water Treatment

Several months ago it was announced in the Australian technical press[1] that a revolutionary method of treating feed water had been discovered in that country. The treatment consisted simply in allowing the water to flow over inclined aluminum plates in the presence of sunlight. Under these conditions the molecular or intermolecular conditions of the scale-forming elements are so changed that instead of forming a hard crystalline scale on the boiler tubes, the deposit is a powdery amorphous mass which can either be washed out of the tubes, or is blown out of the mud drum when blowing down the boiler.

The Australian Apparatus

As used at the Broken Hills Proprietary Company, the apparatus consisted of two aluminum sheets, each 2x4 feet in size, fixed in a frame at an angle of 59 degrees and facing the sun. The water to be used in the boilers was then flowed over these plates from a perforated pipe along their upper edge. As the process was only supposed to be effective during the daytime, storage was provided for the water to be used at night.

In all 197,750 gallons of water were treated and used in a specially cleaned boiler, the test lasting 54 days.

The boiler was then opened, and instead of the hard adherent scale which is normally observed after a run of this length there was either simply a whitish powder or a brittle loose scale, while a portion of the boiler had no deposit in it.

The time of cleaning was reduced from 3½ days to eight hours.

American Installations

Several somewhat similar installations have been made in America recently. In these installations, however, a corrugated plate, or a series of aluminum channels has been used. The equipment is being tried by several important industrial organizations; for example, at the Long Island City plant of the Standard Oil Company, and an installation by the West Shore Railroad at Newark, N. Y., the water in this instance being used by the locomotives. These installations have not been in use long enough to give a definite opinion as to the value of the operation, but the important character of these two corporations indicates that the matter may be worth following up.

It may be noted in this connection that the Watson-Stillman Company, of New York, is putting on the market a compound claimed to be a natural mineral product "consisting mainly of iron, alumina and silica," which is fed into the boiler in suitable quantity at each stroke of the feed pump. It seems to be the general assumption that aluminum hydroxide is partly responsible for the results obtained, as suggested under the idea of protective colloid below.

On Feb. 24, 1911, Thomas R. Duggan, of London, lectured on this new process before the Society of Chemical Industry, adding somewhat to the information already made public. The form of the apparatus shown was that with corrugated aluminum plates, but the corrugations are apparently more to insure thorough distribution of the water than for any other reason. There is a hopper at the top, from which a number of small nozzles, one to each trough, feed the water to the plate. The hopper is furthermore provided with a screen to keep large pieces of dirt and grit from choking the nozzles.

The plates should be open to the air, and although more active by day, have some activity at night, apparently due to the small amount of ultraviolet radiation even at that time. The plates in the northern hemisphere should face south; in the southern hemisphere, north. It is essential that the pipes and storage tanks used after the water is treated should be, as far as possible, of nonconducting material, and the water should be used as soon as possible after treatment, and should be used by the seventh day, as a maximum. It is also essential that the plates should be given a rest occasionally; where hard water is being treated, every plate is allowed to rest one day per week.

It is stated that the plates become positively charged, and the water negatively, and this, when considered in conjunction with the fact that the plates should face either north or south, and that a nonconducting material should be used for the storage tank, leads to the belief that some fundamental change in ionization is responsible for the results. However, a minute amount of the aluminum dissolves, and researches with the ultra-microscope show that it remains in colloidal solution, though whether as a mixture of aluminum and aluminum hydrate, or the latter only, seems open to question. Whichever of these it may be, the explanation of protective colloids seems also possible.

The apparatus is made in units about 6 inches wide, one 6-inch unit having a capacity of about 1000 gallons per hour. The advantages claimed for the treatment are: It is automatic, continuous and uniform; no chemicals or heat used, hence low treatment cost; it has no action itself on the boiler, and by a deoxidizing effect on the water is a preventer of corrosion; hard scale is prevented and the time of cleaning the boiler much lessened, thereby getting more hours' work from a given plant; by the elimination of hard scale the efficiency and life of the boiler are claimed to be increased.

Any water is amenable to this treatment except that containing ferrous sulphate or carbonate. With saline waters the length of the plates is increased beyond the usual 5 feet, or the water run back over the plates several times. Boilers under this treatment must be blown off frequently, particularly during early stages, as old scale often loosens and settles into the mud drum during the first few weeks.

The process is the invention of Herr Brandes, and is patented in most civilized countries, the rights for the United States being held by the Luminator Water Company of America, with officers in New York.

[1]Aust. Min. Std., Sept. 21, 1910.

Congress of Technology

A congress of technology will be held in Boston on April 10 and 11 in celebration of the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology. In line with this idea, the fifty or more papers which will be presented at the congress will be written by graduates of the institute, and will thus serve to record the part the alumni of the institution have taken in the development of scientific industry.

As the titles of these papers are sent in by the writers, it is becoming evident that the managers of the congress will succeed in their effort to make the proceedings show from another point of view the general industrial advance that has taken place during the past fifty years under the guidance of trained engineers. The papers will cover a wide range of subjects, from architecture to sewage purification, and the names and professional standing of the writers show that they will together discuss authoritatively every important problem of modern industrial technique and management. It is already clear that this record is not limited to any narrow activity within merely technical lines, but that it covers the broader problems of the relations of science to industry, and the place of the engineer in creating a more efficient type of industrial management.

The point is made that by a slight change in the arch of a furnace under a tubular boiler, much can be done to prevent smoke. The proper length and form of the combustion arch depends upon many variable factors and perhaps is best determined by experiment under the given conditions. A station was equipped with a pair of automatic stokers, and it was thought they were installed exactly alike. One unit made smoke and the other did not. On taking measurements it was found one arch was 6 inches higher than the other. The high arch was dropped 6 inches and the smoke stopped. If the draft had been a great deal more, the arch might have had to go up.—*Ex.*

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Samson Transmission Rope

This rope is composed of a special crucible cast-steel wire rope coated with a rubber compound over which is braided, under heavy tension, a cotton cover comprising about four-fifths the area of the rope. The compound in the rope is vulcanized, which causes it to expand and harden into the interstices of both the cotton and wire ropes, firmly binding them together, also waterproofing and lubricating that portion of the rope most subject to deterioration. A final operation is to treat the cotton with a penetrating finish, binding its fibers together and increasing its resistance to wear. Fig. 1 shows the construction of the rope.

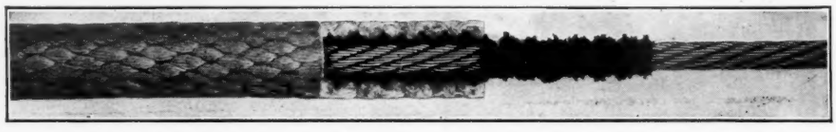


FIG. 1. DETAILS OF CONSTRUCTION

The method of splicing this make of rope is such that every wrap can be fitted with a coupling to exact length, by any mechanic at any convenient bench, and then coupled or uncoupled in working position on sheaves. This makes it possible to cut spare ropes at the exact length required and fit them with the coupling ready to be attached. Unlike rope that requires splicing, it is not necessary to make each rope endless in working position while the drive is idle, nor is it necessary to shorten it up after installation.

The rope coupling is composed of two thimbles and a connecting sleeve, as shown in Fig. 2. Each end of the rope is cleaned bright, then passed through a thimble and expanded by driving a rivet, and turning the wire ends into the socket, after which all space between the wires is filled with solder. It is claimed that a ¼-inch coupling will resist a ton strain. The coupling and wire center, which carry the strain, never come in contact with the sheaves, as the cotton cover protects them.

This transmission rope and coupling is made by the Samson Cordage Works, 88 Broad street, Boston, Mass.

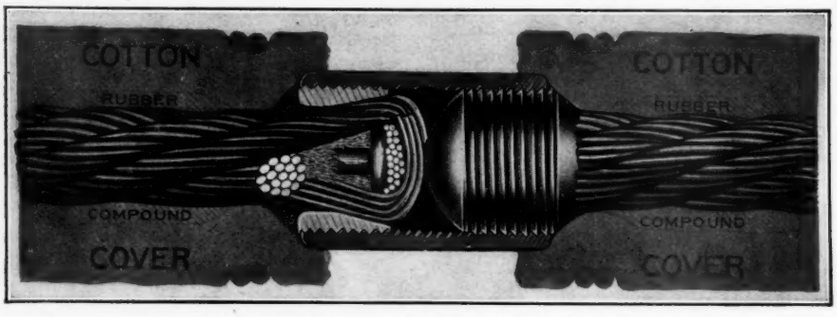
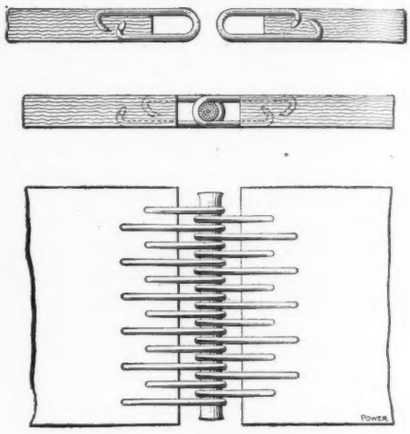


FIG. 2. COUPLING JOINT

Clipper Belt Lacing

This lacing constitutes a simple and effective means of fastening belts, and is easily and quickly applied. The lacing is done with a series of hooks of a size corresponding to the amount of power to be transmitted, these hooks hinging on twisted rawhide pinions. The lacer itself consists of a solid steel base and anvil, with lacer part of bronze metal, and a solid lignum vitae mallet. The advantages claimed for this lacing are that both sides of the belt are perfectly smooth, it uses hooks having a long and short side, thus equalizing the strain, the joint is flexible, with no chance of crystallization of the hooks if they are properly driven into the belt flush with the surface, and no short ends of belts are wasted in making the lacing. Any width or thickness of belt may be laced with the same tool and as it is portable it is easily taken to the point where the work is to be done, making it unnecessary to take the belt off the shaft or pulleys.

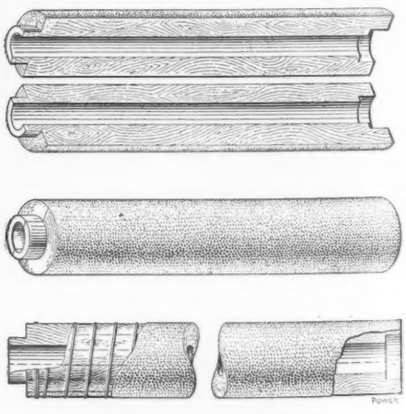


CLIPPER BELT LACING

The Clipper belt lacer is manufactured by J. B. Stone Company, Grand Rapids, Mich.

Improved Steam Pipe Casings

An efficient nonconducting covering is made by the Michigan Pipe Company, of Bay City, Mich. The casings are made of staves, which it is claimed have proved successful in every respect. The stave casings, which are illustrated in the accompanying drawings, are made in sections up to 12 feet in length, of Michigan pine and tamarack. The inner and



STEAM-PIPE CASING

outer surfaces of the staves are curved to conform respectively with the inside and outside circles of the pipe and the sides are fitted with a double tongue and groove, running the full length of the pipe. The staves are thoroughly inspected, and assembled in a cylindrical form, after which the sections are spirally bound with galvanized wire from end to end, under heavy tension, with a double wrap at each end, thus making them of uniform strength and as rigid as the solid log. A mortise is then put in one end and a tenon on the other, after which the outer surface is heavily coated with an imperishable cement.

Smaller sizes of casings are made of solid logs which are bored and then finished the same as the stave casings.

The Kilgour Boiler Setting

Barristers hall in Boston is so situated that its smokestack is one of the prominent features of the view from the smoke inspector's window. As a consequence Dwight Kilgour, the mechanical engineer in charge, made numerous involuntary excursions to the court where violations of the smoke ordinance are tried, each entailing considerable unpleasantness, not to mention the expense incurred in the shape of lawyer's fees and time. Convinced that the only way to stop the arrests was to stop the smoke, he directed his activities to the production of a smokeless furnace.

If one sits in a room with a lamp having a chimney like that shown in Fig. 1, he will soon be sensible that the lamp is there. If the chimney is extended into the usual converging nozzle, the combustion will be complete and the flame bright and steady. Mr. Kilgour compared his smoky furnace with the smoky lamp and concluded that it needed its chimney lengthened; not the tall brick stack beyond the boiler which carries off the products of combustion, but the firebrick inclosure in which the combustion should be completed before the gases

FIG. 1. A CASE OF CHILLING THE FLAME

reach the cool boiler plate and tubes.

He therefore threw up a firebrick curtain *M* behind the bridgewall and led the converging firebrick tube or arch out of it as shown in the views of Fig. 2. The bridgewall was made hollow, and cast-iron ducts *M* with perforations pointed toward the rear of the boiler discharge finely divided streams of highly heated air into the gases as they stream over the bridgewall.

One observer said that he had simply changed the ordinary brick arch from the furnace to the combustion chamber. Even so, he gets away from that disadvantage of the furnace arch that it radiates heat upon the firebed with such intensity that it accelerates the throwing off of the volatiles which already come off from freshly fired fuel faster than they can be burned. With the arch located back of the bridgewall, all the products of the furnace, including the volatiles, have to pass through it; and, if they are hot enough, if there is oxygen enough present and if the mixture is sufficiently intimate, the combustion will be complete.

After the furnace has been running for a while the mass of brickwork becomes incandescent. The gases coming directly from the furnace and with no chance of losing heat except to the shell directly over the furnace, can easily be kept above the point of ignition while passing through the passages of red-hot brick. The presence of sufficient oxygen may be secured by the admission of air above the bridgewall, and as this comes

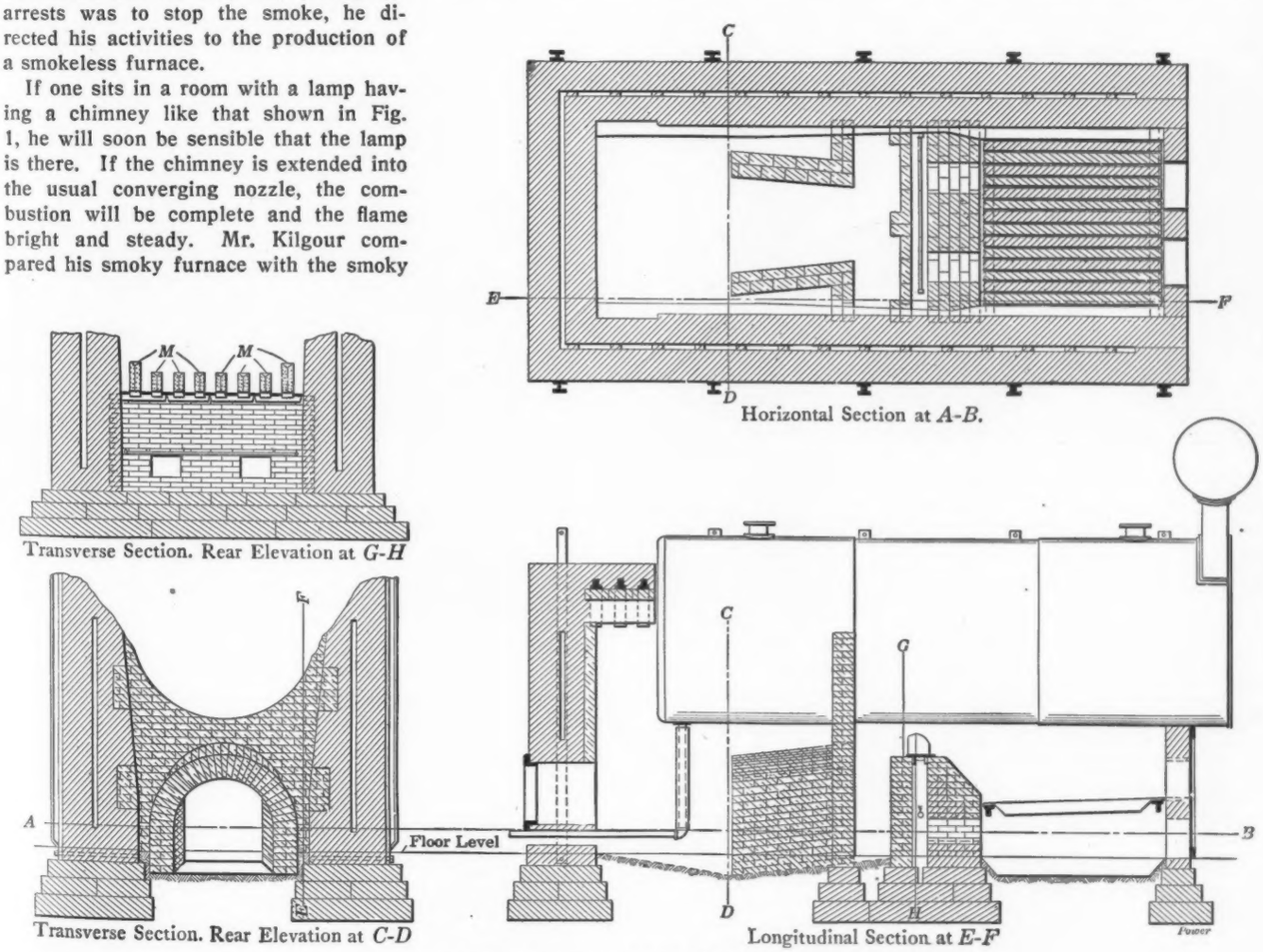


FIG. 2. SECTIONAL VIEWS OF THE KILGOUR BOILER SETTING

in a highly heated condition its introduction does not cool the gases below the temperature at which they will unite. The diffusion of the air in numerous jets tends to an intimate mixture, which tendency is enhanced by turning the sheet of gases which is flowing over the bridge-wall in a sheet the width of the furnace, so that they pass out through a passage which is quite some higher than it is wide. This change from a horizontal to a vertical plane produces a swirl in the current which is very pronounced as their combustion in the extension tube is watched from the rear. There is no impingement of the flame upon the shell, and yet no loss of efficiency in the heating surface, for the shell above the arch receives radiant heat from it as it would from an equally hot mass of glowing coal.

C. E. Cotting is the trustee of numerous estates owning large buildings, and Mr. Kilgour is his mechanical engineer. He has therefore had an exceptional opportunity to try out his ideas under various conditions. I saw them at the Exchange building carrying fires of soft coal piled nearly to the top of the fire doors. I watched at the back connection while they put on fresh fuel and sliced the fires. Each shovelful of coal as it was fired produced a rush of flame in the arch as though a jet of gas had been turned on momentarily. The slicing filled the whole back connection with a roaring mass of flame, which, however, cleared up instantly. The stack showed a very thin gray smoke at intervals, evidently when the fires were disturbed.

They have burned as high as 25 to 30 pounds of coal per square foot of grate, and after three years of use the arches are in good condition with no rebuilding or repairs. The perforations in the iron retorts require drilling out from time to time. The brickwork becomes covered with a black vitreous crust to which clusters of slag attach themselves, which may, however, be picked off with the fingers. The furnace has been patented and adapted to water-tube as well as to shell boilers. Henry W. Buhler, 251 Causeway street, Boston, is licensee of the Kilgour patents and controls the manufacture and erection of the setting.

ANNUAL BANQUET OF THE COMBINED NATIONAL ASSOCIATION OF STATIONARY ENGINEERS ASSOCIATIONS OF MANHATTAN AND THE BRONX, NEW YORK CITY

New York Engineers Hold Annual Dinner

Saturday night, February 25, at the Broadway Central hotel, a gay scene was presented when about two hundred ladies and gentlemen sat down to the second annual dinner given by the general committee of the combined associations of the National Association of Stationary Engineers of Manhattan and the Bronx.

John Mahr acted as toastmaster and introduced each speaker and singer in turn with words both pointed and pertinent.

Edward H. Kearney, national vice-president, was the first speaker. He dwelt on the history, aims and triumphs of the National Association, ascribing a good measure of the success attained to the coöperation of the wives, sisters and sweethearts of the members. So eloquently did he portray the effect of this influence that few, if any, of his audience realized that his experience in feminine coöperation had been conducted entirely on the absent-treatment plan.

Charles A. Wilhoft, president of the Supplymen's Association of Manhattan, read letters of regret and of felicitation from prominent members of the national association from various parts of the country, and made a few brief remarks as to the history, aims and scope of the supplymen's organization.

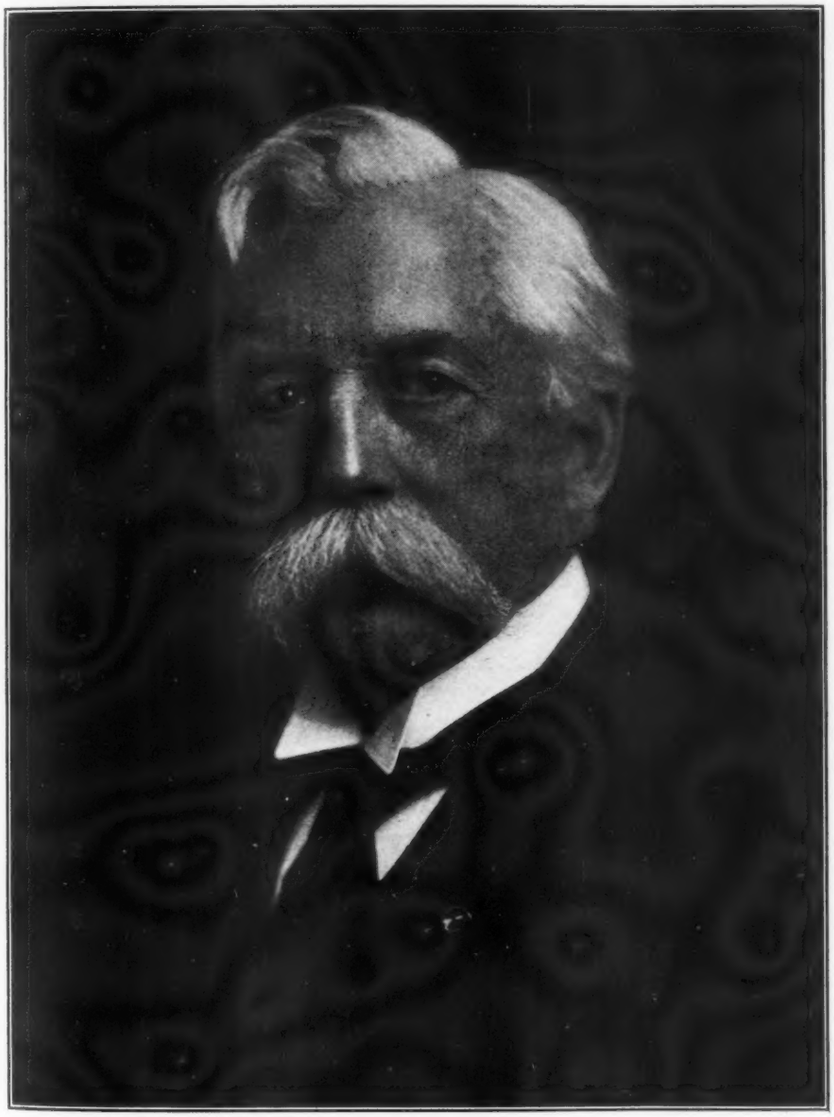
Past National Presidents Carney and Reynolds added gems of mixed wit and wisdom to the occasion and very considerately cut their parts short in order to give all the time possible to Billy Murry and Jack Armour.

Promptly at 12 o'clock dancing began and was continued far beyond the usual "wee sma' hour."

It was the consensus of opinion that the event was both pleasant and profitable and the best ever.

The Newly Elected President of A. S. M. E. for 1911

On May 30, 1841, Edward Daniel Meier, who is now president and chief engineer of the Heine Safety Boiler Company, was born in St. Louis, Mo. A scientific course at Washington University in St. Louis and four years at the Royal Polytechnic College in Hanover gave him a solid foundation on which to build his engineering career. After seeing much active service in the Civil War, Colonel Meier entered the Rogers Locomotive Works, at Paterson, N. J., remaining one year. From 1867 to 1870 he was associated with the Kansas Pacific Railway, first as assistant superintendent and then as superintendent of machinery, leaving there to become chief engineer of the Illinois Patent Coke Company. In 1872 he became manager of the Meier Iron Company, building its blast furnaces, and from 1873 to 1875 directed the machinery department of the St. Louis Interstate Fair. During this time he became actively interested in the St. Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press. In 1844 he organized the Heine Safety Boiler Company for the development in the United States of the water-tube boiler of that name, and has been its president and chief engineer ever since. He was also responsible for the introduction of the Diesel motor into the United States and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Company.



COL. E. D. MEIER

Colonel Meier has been active in a number of professional organizations. From 1881 to 1884 he was treasurer of the St. Louis Engineers Club and president from 1889 to 1890. During the latter period he was also secretary of the American Boiler Manufacturers Association, and in 1908 to 1909 he was president of the association and also of the Machinery and Metal Trades Association.

In the American Society of Mechanical Engineers, Colonel Meier has been active on many committees and has been twice elected vice-president, serving his first term from 1898 to 1900, and beginning the second in 1910, so that he was still holding this office at the time of his election as president.

Low Water Caused Explosion on the "Delaware"

It is reported by the daily press that the boiler accident on the battleship "Delaware" on January 17, which killed nine men, was caused by low water in the affected boiler. According to the findings of the court of inquiry, appointed by the Secretary of the Navy, the water tender, who was killed, was responsible for the condition of the water in the boiler. At the Navy Department it was said that the findings will result in an attempt to devise a plan by which the responsibility for maintaining the water at a proper hight will not be intrusted to water tenders alone, but will be shared by others of the boiler-room force.

Steam Boiler Inspectors Organize

On the evening of February 21, following a dinner at the Victoria hotel, New York City, the steam-boiler inspectors employed in and around the city, organized a society which adopted the name of the American Institute of Steam Boiler Inspectors. The dinner was attended by a large number of inspectors employed by the several insurance companies, railroads, etc., in and around New York, together with representatives from a similar society of Boston, Mass., including its vice-president, J. F. Molloy, who outlined the value of the society and the good work that is being done. James G. Shaw read a paper defining the purposes and aims of the institute.

After an informal discussion a constitution was adopted and the following officers elected: President, T. T. Parker; vice-president, J. N. Winter; secretary, Robert A. Thomson; treasurer, T. McGowan.

An executive committee of five was chosen, and the organization will be completed at an early date. The list of charter members contains thirty-six names, but it is expected that when the purposes of the society are fully understood by the inspectors not present, the membership will be greatly increased and embrace practically all those in the immediate vicinity of New York.

The society is for steam-boiler inspectors employed by Federal, Dominion, State and city governments and the insurance companies of the United States

and Canada, but the charter list is open to actual boiler inspectors only.

The object of the institute is to promote the educational and social interests of its members, and, to this end, meetings for presentation and discussion of papers will be held at regular intervals.

This is the second society of this nature formed in this country, but owing to the success of the Boston organization, steps are being taken to make the institute one which shall include in its membership all of the reputable boiler inspectors in North America.

The address of the secretary is 1 Madison square, New York, N. Y.

SOCIETY NOTES

The Oregon Society of Engineers has been organized with a charter membership of 160. All branches of the engineering profession are included in the membership. The territory has not been limited to the State of Oregon, but includes all the Greater Northwest. D. C. Henny, 605 Spaulding building, Portland, Ore. (consulting engineer for the United States Reclamation Service), has been elected president, and G. L. Bliven, 407 Buchanan building, secretary. The present headquarters of the society will be located at 407 Buchanan building, Portland.

The ninetieth meeting of the National Association of Cotton Manufacturers will be held at the Massachusetts Institute of Technology, Boston, Mass., April 12 and 13, 1911. These dates have been selected because they immediately follow the Congress of Technology which will be held on the preceding days, in celebration of the fiftieth anniversary of the charter of that institution, and it is expected that many of those present will remain to attend the meeting.

President Maclaurin, of the Massachusetts Institute of Technology, will speak at the opening session and during the meeting papers are expected on the following subjects: "Arbitration on Cancelation of Orders," "Byproducts in Cotton Manufacture," "Doffing Machines and their Relation to Child Labor," "Electric Power Transmission to Cotton Mills," "Executive Management of the Textile Plant and its Relation to the Market," "Gas Producers and Gas Engines for Cotton Mills," "Illumination," "Law of Moisture in Cotton and Wool," "Methods of Cost Finding in Cotton Mills," "Moisture in Cotton," "Renaissance of the Waterfall," "Rewinding Weft Yarn," "Sandwich Island Cotton," "Textile Education from a Manufacturing Standpoint," "Weaving Shed Roof Construction."

Also reports on standard specifications and other subjects by special committees.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

INTERNAL COMBUSTION ENGINE. Geo. F. Murphy, Jersey City, N. J., assignor to Fuel Oil Engine Company, Providence, R. I., a Corporation of Rhode Island. 984,695.

ROTARY ENGINE. Ambrose Everts Greene, Pueblo, Colo. 984,901.

ROTARY ENGINE. James Henry Watson, Riverton, Wyo. 984,983.

ROTARY ENGINE. Karl Wittig and Emil Wittig, Zell, Wiesenthal, Germany. 985,091.

BOILERS, FURNACES AND GAS PRODUCERS

WATER-TUBE BOILER. John E. Bell, New York, N. Y., assignor to the Babcock & Wilcox Company, New York, N. Y., a Corporation of New Jersey. 984,880.

FURNACE. Joseph Harrington, Riverside, Ill. 984,910.

SMOKE-CONSUMING FURNACE. William E. Ludlow, Washington, and Henry J. White, Augusta, Ga. 984,979.

POWER PLANT AUXILIARIES AND APPLIANCES

BOILER-TUBE CLEANER. Thomas S. Waller and John V. Carr, Detroit, Mich., assignors to Raphael Herman, Detroit, Mich. 984,622.

LUBRICATOR CUP. Robert M. Stevenson, Olean, N. Y. 984,713.

FINE FUEL-FEEDING APPARATUS. Geo. L. Swift, Chicago, Ill. 984,715.

VALVE. William Gavin Taylor, Waterbury, Conn. 984,718.

ENGINE INDICATOR. Max Arnot, Aixla-Chapelle, Germany. 984,732.

VALVE MECHANISM. John W. Ledoux, Swarthmore, Penn. 984,820.

LUBRICATOR. Oscar H. Neiman, Freeport, Ill. 984,839.

PISTON-PACKING EXPANDER. George Christenson, Nevada, Mo., assignor to H. W. Johns-Manville Company, a Corporation of New York. 984,888.

NOISE MUFFLER FOR EXHAUST PIPES. Daniel W. Dudderar, Mount Airy, Md. 984,890.

BOILER FLUE-CLEANER SYSTEM. De Los E. Hibner, Dubois, Penn., assignor to the Vulcan Soot Cleaner Company of Pittsburg, Penn., Dubois, Penn., a Corporation of New Jersey. 984,919.

SAFETY DEVICE FOR STEAM ENGINES. Walter B. Kollar, Lansing, Mich. 984,935.

SEPARATING GRATE. Nicholas Colgen, St. Charles, Minn. 985,007.

BOILER FEEDER. George C. Miller, Fitchburg, Mass., assignor to the Leominster Machine Supply Company, Leominster, Mass. 985,050.

PISTON HEAD. Frank Pienie Roesch, Douglas, Ariz. 985,065.

ELECTRICAL INVENTIONS

ELECTRIC HAMMER. Hilary F. Whalton, Key West, Fla. 984,984.

ALTERNATING-CURRENT MOTOR. Burton McCollum, Lawrence, Kan. 984,582.

ELECTRIC WELDING MACHINE. Lafayette M. Pryor and Jesse L. Trapp, Frankfort, Ind. 984,603.

VAPOR ELECTRIC APPARATUS. Max Von Recklinghausen, New York, N. Y., assignor to Cooper Hewitt Electric Company, a Corporation of New York.

ELECTROMAGNETIC APPARATUS. John P. Coleman, New York, N. Y., assignor to the Union Switch and Signal Company, Swissvale, Penn., a Corporation of Pennsylvania. 984,748.

VARIABLE SELF-INDUCTION COIL. Allyne Clark Hovey, Pittsburg, Penn., assignor of thirty-one-hundredths to Walter Rosenbaum and thirty-one-hundredths to Herman S. Heymann, Pittsburg, Penn. 985,009.

POWER PLANT TOOLS

WRENCH. Hiram Mendenhall and Bertel R. Wonsmos, Audubon, Iowa; said Wonsmos assignor to John Weighton, Audubon, Iowa. 984,691.

WRENCH. Eugene Green, San Marcos, Tex. 985,028.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting in Pittsburg, May 30 to June 2.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York. Next meeting in New York City, May 29 to June 2.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Commander U. T. Holmes, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., O. P. Chamberlain; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., Walter Riddle; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Pres., R. P. Bolton; sec., W. W. Macon, 29 West Thirty-ninth street, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June 5-10, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting at Detroit, Mich., January, 1912.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

A very curious case was called to our attention the other day.

It illustrates a great and universal advertising truth and we believe it will interest you.

A few years ago *Rubifoam* was a national tooth wash. It was sold and used practically all over the country. The girl with the dazzling smile, holding a bottle of *Rubifoam* in her hand, was about as well known as,—well, say as Peary was after the discovery of the North Pole.

But suddenly the girl with the dazzling smile disappeared from public view. *Rubifoam* was no longer advertised.

Some advertising men decided to go after the manufacturer of *Rubifoam* and find out what caused the trouble.

He lived up in New England somewhere, as we remember it.

At any rate the advertising men found him.

"What's the matter; have you lost your nerve; don't you believe advertising pays?" they asked him, together with a torrent of other questions.

He shook his head and smiled. "Oh, yes, I believe in it—thoroughly."

Naturally, his questioners were dumfounded.

"Well, then, what in the world's the matter?" they inquired.

"Well, gentlemen, it's this way," he began. "I've built up this business entirely myself. I have no one to whom to leave it. I have no idea how it will be run after my death—whether the standard of the product will be kept up, etc. So I've just dropped advertising and the business is slowly dying. I figure by the time I'm ready to go the business will be about finished, too."

The advertising men tried to argue with him, told him it was his duty to the community to continue advertising and used similar arguments, but they failed to budge him from his peculiar position.

Now, this story has a very direct bearing on the products you see advertised in the pages of this—your paper.

For suppose all the manufacturers of power-plant apparatus decided that for some reason or other they would let their businesses die.

Imagine what a quandary you'd be in as to where you'd buy the things that are absolutely essential in your work.

There was a time when man was almost entirely independent of other men.

He tilled his own ground (or rather his wife did), raised what vegetables or fruits he needed and killed what meat he wanted and clothed himself with the skins of the animals he killed.

But with the advance of civilization man's dependence on his fellow men has increased.

Today he could not find work or proper rest and nourishment, hardly could he find sufficient food without the support of his fellow-men whom he in turn supports.

Advertising is interwoven as a vital part of life in these modern times.

If all advertising ceased, think of the effect! What a groping around in the dark there would be for the things we need in our existence and our business. We would hardly know where to find them.

Of course, just because the maker of a tooth-wash stops advertising and lets his business die does not make much difference in the sum-total of affairs one way or the other.

But suppose the exclusive manufacturer of some really vital and necessary thing should do the same.

We then arrive at the conclusion that it is the duty of such a manufacturer to advertise his product.

But it is also the duty of the man interested in that product to at least give it his attention—to consider it.

Cooperation is a necessity of modern business.

BUSINESS ITEMS

The Albany Lubricating Company, Adam Cook's Sons, proprietors, maker of Albany grease, has moved into its new office and factory building recently completed for it at 708-710 Washington street, New York City. The business of this company was established at Albany, N. Y., in 1868; the business was moved to New York City in 1872, where it has had its home ever since. A cordial welcome is extended to all our readers to visit the new home when they are in New York.

The Yale & Towne Manufacturing Company has been awarded the contract for installing a complete monorail overhead tramway system for the J. H. Ladew Company's new tannery, Plank road and Passaic river, Newark, N. J. The equipment comprises about three-quarters of a mile of I-beam, three traveling cranes, transfer devices, automatic fire-door attachments, etc., and is notable as showing the tendency toward overhead or aërial transportation for the handling of materials in uptodate manufacturing establishments.

The Westinghouse Electric and Manufacturing Company has received a contract from the Perine Machinery Company, Seattle, Wash., for four alternating-current induction type CCL motors to be used in operating exhauster fans for removing chips, shavings, sawdust, etc., from the joiner and boat shops at the Puget Sound navy yard, Bremerton, Wash. The fan motors will be overhung on the motor bearings; this direct connection of the units is probably the most interesting feature of the work. The four motors will have capacities of 10, 15, 50 and 75 horsepower each. The work in connection with the installation of the motor-driven fans will be done under the cognizance of the Bureau of Construction and Repair, Navy Department.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

ENGINEERS WANTED to solicit for the Rolin patent adjustable grate. Apply Standard Grate Co., Heed Bldg., Philadelphia.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

SALES AGENTS to sell steam turbine blowers, feed water regulators, ventilating fans, pumps, etc.; guaranteed territory; commission. Wing, 90 West St., New York City.

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WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

AGENTS WANTED—To sell lubricating oils, belts, hose, paint, varnish, to factories, mills, stores, threshers; exclusive territory to right party; experience unnecessary. Manufacturers Oil & Grease Co., Cleveland, O.

DRAFTSMEN WANTED—Power house men experienced in modern steam practice, also electrical men on high tension generating and substations, near Philadelphia; give experience, reference and salary expected. Box 396, POWER.

THE ENGINEERING SUPERVISION COMPANY wishes to engage a competent technically educated business getter, one living in New York City preferred. Apply at new office, 366 Fifth avenue, New York City, after Monday, February 27, 1911.

OPERATING ENGINEER for alternating-current central station having steam turbines; steam and boiler experience, preferably turbine required; new station and permanent position; send references. Fulton Light, Heat and Power Co., Fulton, N. Y.

WANTED—FIRST CLASS SALESMAN for steam traps. Must be acquainted with the jobbing trade. To a man who is at present employed with a first class house, and engaged in selling steam traps, and who wishes to put himself in the way of advancement, we offer an excellent opportunity. He must be a man of energy, ability, good personality, and with a large acquaintance among the trade. We are willing to demonstrate to any applicant the possibilities of this trap, which as a seller is far ahead of anything that has even been put on the market. Please do not answer unless you can meet the requirements enumerated above. All communications will be considered absolutely confidential. Address Post Office Box 1027, Providence, R. I.

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Advertisements under this head are inserted for 25 cents per line. About six words make a line.

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WANTED—Position by young married man, familiar with a.c. and d.c. in parallel and all makes of engines and boilers; references. Box 380, POWER.

STEAM ENGINEER, experienced with slide valve and Corliss engines; I own my indicator; have I. C. S. diploma; will do my firing in small place; references given from present place. Roy C. Smith, St. Elmo, Ill.

CHIEF ENGINEER—Years of experience with high-pressure superheated steam, steam turbines; experience in erection of steam plants; as to salary try me first, if I don't make good, don't pay. Box 392, POWER.

MECHANICAL SUPERINTENDENT, 20 years' experience in textile manufacturing, cotton goods, print works, dye works and bleaching; capable of taking full charge of mechanical and electrical departments, also construction. Box 390, POWER.

MECHANICAL ENGINEER, versed in steam electric power house practice, making specialty of low cost power production, desires to associate himself with parties controlling power plants where such services would be productive of results; location, Middle West. Address Box 395, POWER.

CHIEF ENGINEER and electrician; young man, 28 years; steady, sober and careful; some technical training; eight years' experience with automatic and Corliss engines, a.c. and d.c. generators, motors and lighting; three years with last company, in charge of power and lighting; good references; permanent position in West with light and power or manufacturing company; own indicator and tools; give salary, conditions and nature of plant. Box 16, Route 2, Waverly, Kan.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

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Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Small screw cutting lathe, chuck and tools; fine condition; bargain. South Bend Machine Co., 424 Madison St., South Bend, Ind.

FOR SALE—Electric light plant in growing Nebraska town, pumping city water, new 20-year franchise and street-lighting contract. Box 381, POWER.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—Steam engine, Nordberg automatic governor, which makes this engine equal to Corliss; cylinder 10x15; in excellent condition. Address Tappan Shoe Mfg. Co., Coldwater, Mich.

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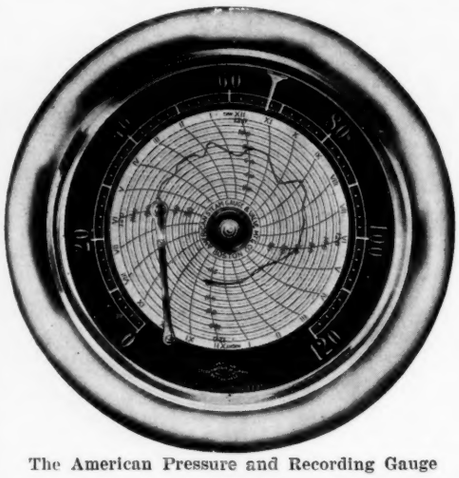
Benefits Engineer and Fireman As Well As The Manager

American Pressure And Recording Gauge



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It proves to the manager whether or not his plant is in capable hands. And that it pays to have this gauge installed in the small as well as the large plant is clearly shown by the following letter.

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We have had the gauge installed for over a year and know that it has *saved us twice the cost in fuel.*

We have a one man plant and can always see each day if he was a live one or a dead one at night. Yours truly,

LOGAN LIGHT & POWER COMPANY

(Signed) E. T. Wagenhala, Mgr.

This practical instrument can be placed anywhere in the plant—in the engine room or in the manager's office. To the manager it is an able assistant, as it supplies him with reliable reports of the work being done in the boiler room. To the engineer and fireman it's a friend at court, as it tells the manager and tells him every day just how capably the work is being done. No matter what your position in the power plant, it will benefit you to have one of these gauges installed. Further details will be sent on request.

American Steam Gauge & Valve Mfg. Company

Boston, Mass.

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Beware of the man who hides behind the "just-as-good-but-cheaper" mask.

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American Steam Gauge & Valve Mfg. Company

Boston, Mass.

New York Chicago Atlanta
Pittsburg San Francisco Los Angeles

American Steam Gauge & Valve Mfg. Co.
Boston, Mass.

Send me full details of your Indicator offer No. 100.

Name . . . . . .

Address . . . . . .

City and State . . . . . .

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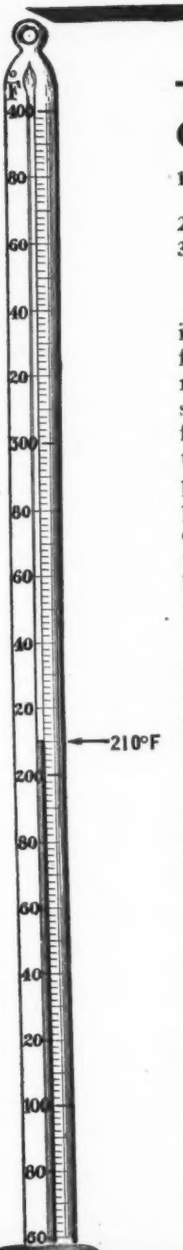
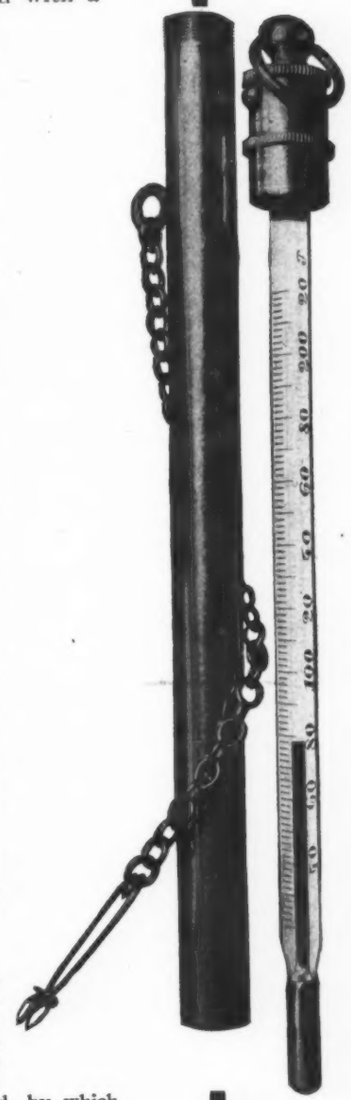


To Obtain One Of These High-Class Engineers' Thermometers

1. **Give the name of the plant in which you are operating engineer.**
2. **The make and kind of feed water heater now in use.**
3. **Enclose ONE DOLLAR in stamps, bill, check or money order.**

The Cochrane Engineers' Thermometer is a high-grade instrument, which could not be bought in the open market for anything like the price named. It is fitted with a nickel-plated metal carrying case, chain and safety pin, and has been especially designed for the use of stationary engineers in measuring the temperature of boiler feed water, the temperature of steam in the condenser, the temperature of the hot well water from the condenser, the temperature of steam in a throttling calorimeter, the temperature of lubricating oil, the temperature of circulating water in heating systems, etc., etc.



It will enable you to discover whether or not you are operating your plant at the highest efficiency. **IF THE TEMPERATURE OF YOUR BOILER FEED WATER IS BELOW 210° F., YOU ARE LOSING MONEY THAT YOU MAY BE ABLE TO SAVE.** Every 10° F. added to the temperature of the feed water represents 1 per cent of the fuel bill saved.

The important question is how many per cent of the fuel bill are you now losing that could easily be saved? With a **COCHRANE HEATER** installed, and supplied with the proper amount of exhaust steam, the temperature of the feed water would at all times be 210° F., or higher where back pressure is carried.

The heating of the water to 210° F. by spraying it through the steam bath of a Cochrane Heater drives off air and gases, which are the more general causes of corrosion.

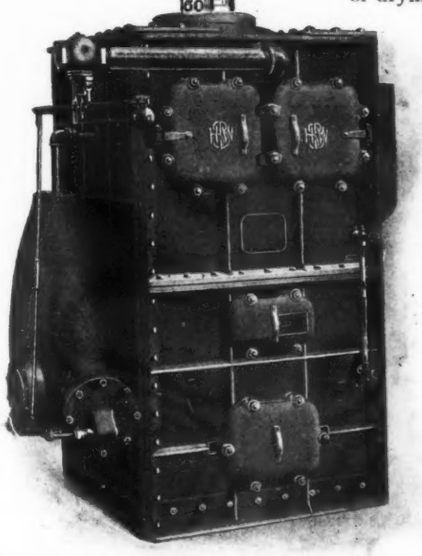
The driving off of carbon dioxide gas changes the soluble bicarbonates into the insoluble monocarbonates, which precipitate out in the heater.

If the water also contains permanent hardness, that is, sulphates, chlorides, nitrates, etc., the

SORGE-COCHRANE HOT PROCESS SYSTEM

will protect the boilers from scale and corrosion, while at the same time giving all the benefits of a Cochrane Open Feed Water Heater.

If you are about to install an exhaust steam heating or drying system, the new Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver will save from $50 to $500 on the cost of equipment.



Most people can bear their hands in water heated to 120° F., and some can go a little higher, but no one can hold his hand in water as hot as it ought to be when it enters the boilers. Send the information specified, together with the **DOLLAR,** and we shall be pleased to send you a thermometer, charges prepaid, by which you can settle these matters definitely. Then you will also receive free a copy of our book on the *"Profitable Utilization of Exhaust Steam,"* in which matters relating to the temperature of steam and feed water, etc., are explained at length.

Harrison Safety Boiler Works

17th & Clearfield Sts., Philadelphia, Pa.

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Minneapolis Steel & Mchy. Co.158
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Two Specialties That Lessen The Trouble Of The Power Plant Engineer

For Leakless Man Holes

One big advantage of using Jenkins Gasket Tubing for manholes, handholes, etc., is that you always have the right size on hand.

By which we mean that you cut off just as much as you need to pack the joint.

No waiting for a special sized gasket to be cut, no waste. You are always prepared for emergencies when you have a supply of this gasketing on hand. And due to its superior construction, being made from a compound similar to that used in Jenkins '96 Packing, it holds the joints tight for a long time. Made in lengths of about 12 feet, $\frac{3}{8}$", $\frac{1}{2}$", $\frac{5}{8}$", and $\frac{3}{4}$" diameter.

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Jenkins Discs enable you to secure more efficient valve service because they last long and consequently make fewer valve repairs necessary.

They are the original *composition* discs, possessing a high quality that cannot be imitated.

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When ordering be sure to specify the right disc for your needs—for instance, order Jenkins Discs No. 100 Hard Composition for STEAM—Jenkins Discs No. 100 Soft Composition for HOT WATER and for check valves in boiler feed lines, etc.—Jenkins Discs No. 93 Soft Composition for Cold Water, Gas or Air. If you are in doubt at all as to which kind to order we shall be pleased to give YOUR requirements our special attention. *Write for Catalog*

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Union Steam Pump Co.....113
Wheeler Mfg. Co., C. H.....112
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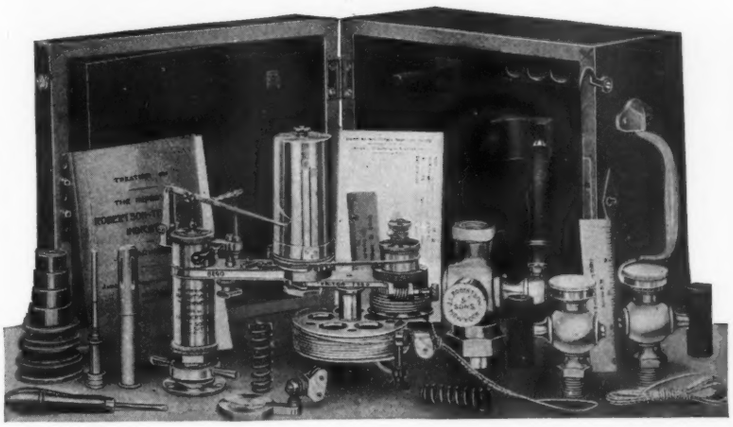

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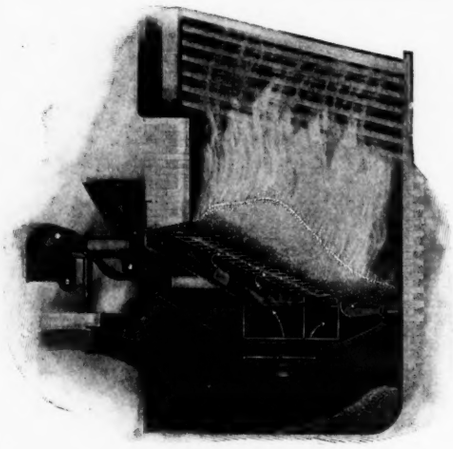

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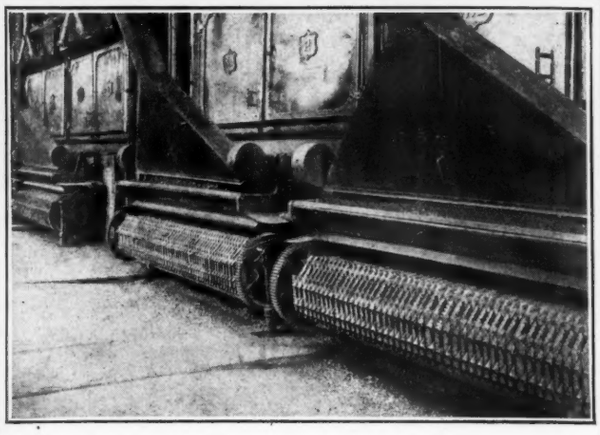

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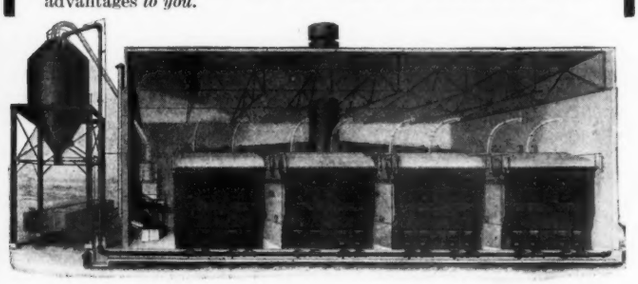

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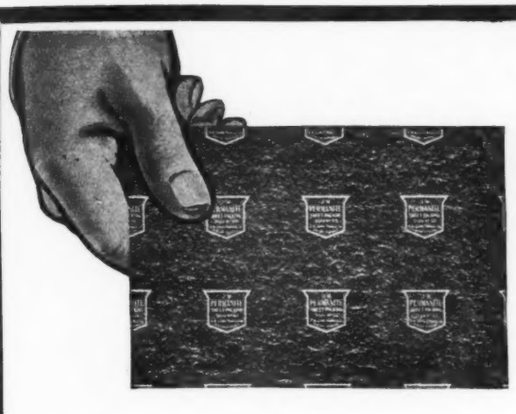

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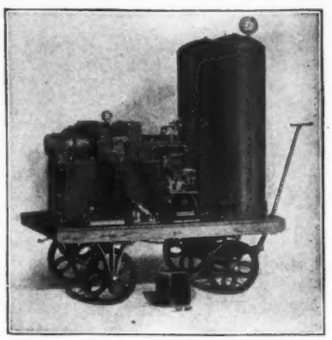

Portable Alternating-current Compressor Outfit.

Machine Shops, Foundries, Power Houses And Many Other Industrial Establishments Are Using Compressed Air

for facilitating the performance of many kinds of work. The cost of a motor-driven Air Compressor is so low and its usefulness so widespread, that no shop can conveniently be without it. Allis-Chalmers Company has issued a handsome booklet telling some of the ways in which its compressors are being used. A copy will be sent on application.

Allis-Chalmers Company

General Offices: **Milwaukee, Wisconsin.**

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Excellent. Economical. U.S. METAL POLISH G. W. Hoffman, Sole Prop. 295 E. Wash. St. INDIANAPOLIS, IND. TRADE MARK. INFALLIBLE FOR POLISHING GOLD, SILVER, PLATED WARE, NICKEL, TIN, BRASS, COPPER, Etc. DIRECTIONS: Take a little of the Polish on a soft cloth, rub the Metal hard and then wipe it off with a dry cloth. No Experiment. A Recognized Success.

A Shining Success

is U. S. Metal Polish. It is the only metal polish which keeps its lustre and is quick and easy to apply. It does not deteriorate. It gives universal satisfaction.

3-oz. Box for 10 cts.
5-lb. Pail, $1.00
1 gal. liquid $1.00.

Sold by Agents and Dealers all over the world.

Write for free sample.

Geo. W. Hoffman
Expert Polish Maker
295 E. Washington St., Indianapolis, Ind.

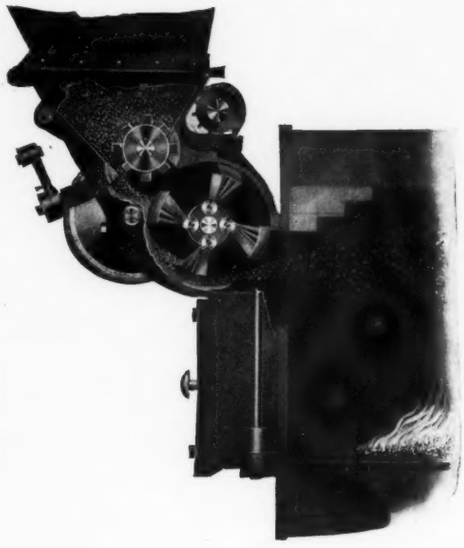
Branches: New York City; Chicago, Ill.; San Francisco, Cal.

Are You?

Are you reading the "Moments With The Advertising Editor" every week? Some men have declared it's one of the most interesting and instructive pages in the paper. Turn to it *now* and read it. You'll find it on page 65 this week.

Continuous And Even Distribution Of The Fuel Over The Entire Surface Of The Grate

secures the most perfect combustion possible; enables you to use a cheaper grade of fuel and generate more heat for every ton used; and maintains the furnace at any uniform temperature desired, thereby giving increased efficiency and protecting the boiler from sudden changes. This is one of the features of

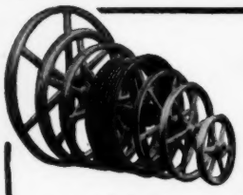


Vulcan Mechanical Fuel Feeders

Another distinctive feature is that Vulcan Feeders do not necessitate the throwing out of good equipment. They can be attached to any boiler front, and do not require special grate or special depth of ashpit. They do not protrude objectionably into the boiler room. This reduction of initial outlay, combined with greatly reduced maintenance cost and more efficient stoking, makes the Vulcan the most satisfactory for all power plant owners, whether the plant be large or small.

Send today for Catalog.

The Vulcan Furnace Company, Warren, Ohio



Jeffrey Sheaves

V and U grooved, accurately turned, bored and balanced. Stock sizes 12″ to 108″ diameter, grooved 1″ to 12″.

Special sizes made to order.

Elevators, Conveyers, Screens, Crushers, Chains, Sprocket Wheels, Gears, Belting, etc.

Write for Catalog 81 describing complete line of Power Transmission Machinery.

The Jeffrey Mfg. Company
Columbus, Ohio

We can elevate and convey your

COAL AND ASHES a distance of 100 feet for less than **ONE CENT A TON**

in quantities of ONE TON A MINUTE or more.

Catalog Free

THE C. O. BARTLETT & SNOW COMPANY, Cleveland, Ohio.

HAMMEL OIL BURNERS

Over 7500

In Use Under Stationary Boilers, Locomotives, Kilns, Etc.
Write for Circular of Hammel Patent Furnace for Water-Tube Boilers

HAMMEL OIL BURNER CO.,
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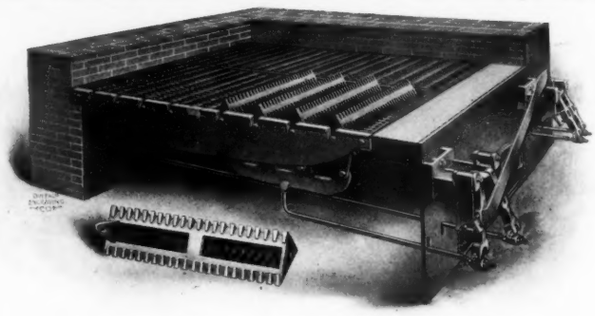


Double Grate Area—No Lost Fuel

Uniform Heating Of Both Sides Prevents Warping

Every bar on the LONG DUPLEX SHAKING GRATE has two usable sides.

Two usable sides to each bar means double area, double life—and at the price of one grate.

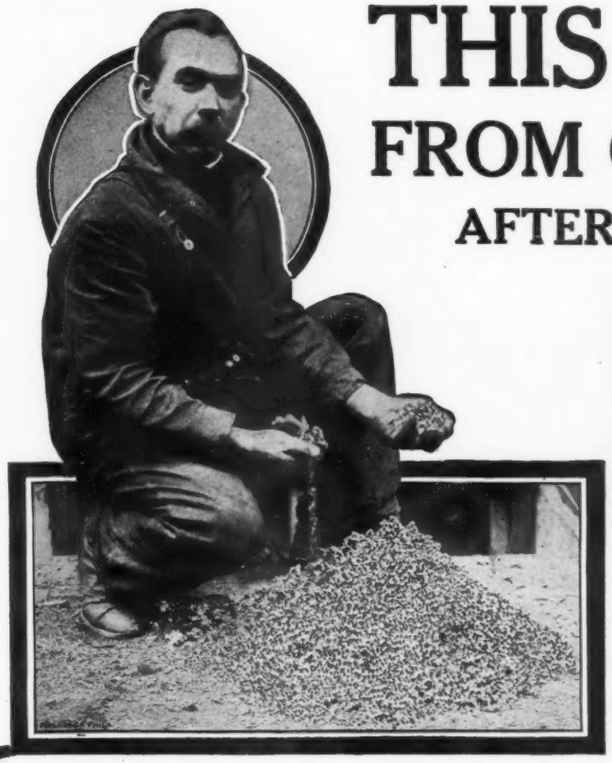
The crushing and raking effect when shaking prevents oss of fuel and permits shaking to extreme position.

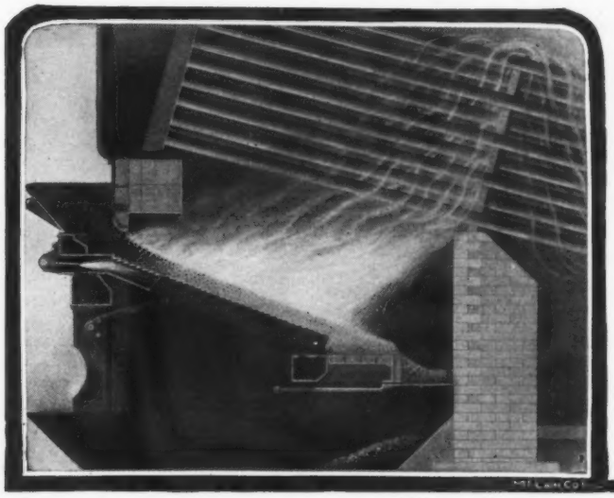
It can be easily installed by any engineer under any kind of a boiler without altering the fire box.

Write *today* for list of successful installations, prices, and full particulars of the "two-in-one" grate.

The Long Grate Bar Company
Buffalo, N. Y.

THIS IS THE ASH FROM CHEAP 50c. COAL AFTER BEING BURNED ON A





WILKINSON AUTOMATIC STOKER

AND there's nothing *but* ash.

The engineer took these couple shovels full shown in the picture right off the ash table of a Wilkinson Stoker and he's sifting a handful through his fingers to show how completely consumed it is.

Now just stop and consider for a second the real significance of this illustration.

Are the tons and tons of coal you consume consumed as completely as *this*?

If you could increase the efficiency of the coal you are *now* using it would be a big source of economy.

But if you thought there was a device by which you could get greater combustion than you have at present and at the same time use a much cheaper grade of coal wouldn't you consider it at least worth investigation?

That's just what these Wilkinson Stokers have been doing for the last 21 years—paying for themselves both in the decreased cost of coal and increased efficiency from the cheap coal.

The Wilkinson is the only stoker made which will burn anthracite coal and the only stoker which will handle small fine coal such as this ash is from.

This coal costs us 50 cents F.O.B. at the mines and $1.25 for freight.

Figure up what such a decrease in coal bills in your plant would amount to and you'll see how quickly the Wilkinson will pay for itself.

We wish we could show an actual photograph of the fire itself, for it is impossible to convey in a picture just how completely this Wilkinson Stoker accomplishes its work.

The coal, by an almost imperceptible motion of the bars, is fed down an inclined surface, where it is gradually consumed, until it finally reaches the ash bed and thence into the ash pit and removed.

A great deal higher degree of combustion is accomplished by a series of steam jets, which create a forced draft by which air is drawn into the hollow grate bars and out through the coal. At the same time this steam acts as an excellent preservative of the grate bars themselves, very materially prolonging their usefulness by preventing them from so readily burning out.

This preservation of the bars is an enormous source of economy, but we have gone still further in this direction by constructing the bars so that the face is removable in three separate castings. The advantage being that should the face of the bar burn out, instead of the $15.00 to $20.000 expense of a new bar, you renew simply the face itself at an expense of maybe $3.00 or so.

There are a hundred and one other advantages to this stoker which we would like very much to send you if you'll write us a line giving your name and address, or to save you a letter we've attached a coupon which you can simply sign and mail.

Will you do one or the other right now?

The Wilkinson Foundry & Mfg. Co.,

Manufacturers of Wilkinson Automatic Stokers and American Feed Water Purifiers

Bridgeport, Montgomery County, Pa.

AGENTS WANTED—We want reliable agents in all parts of the country, and will correspond with you, if interested, for exclusive territory.

COUPON

Gentlemen:—You may send me catalog and testimonials on the Wilkinson Stoker, adv. POWER, March 7, 1911.

Name.....

Firm name.....

Address.....

No. of boilers.....

Type.....

H. P.....

A Case Where Coal Is More Than "Mere Coal"

TO those who do not understand the underlying scientific principles of steam production, coal is but *coal*. Being a natural product—not manufactured—they assume that coal must be measured by weight only. This is not so.

It is the constant aim of the Pennsylvania Coal and Coke Company to supply full heat value, dollar for dollar, in every ton of **Pardee Coal.**

For this reason many large consumers in the East pay a liberal premium for it.

We have favorable freight rates to all Eastern and New England points, and can offer many advantages to large and small consumers of steam coal.

From the forty-nine mines in operation

PARDEE BITUMINOUS COAL

represents but a part of the output. These mines produce coal for all purposes.

Pardee Coal, one of the highest grade coals mined by the Pennsylvania Coal and Coke Company, is one of the best steaming coals produced in Pennsylvania.

Being low in sulphur and ash, **Pardee Coal** makes exceptionally high grade steam coal—an economical coal whether used in large quantities or small.

If you are a steam coal user, we should be pleased to communicate with you concerning your coal problems. The services of our chemist or mechanical engineer are at your disposal without charge.

Send for our booklet "B" on the Engineer's Problem in Selecting Coal.

PENNSYLVANIA COAL & COKE COMPANY

T. H. WATKINS, Receiver

WHITEHALL BUILDING, NEW YORK

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Koerting Steam-Jet

FURNACE BLOWER

This blower offers a means of burning low-priced fuel (which cannot be burnt with natural draft), such as screenings, gas works breeze and other refuse, thereby making a direct reduction in cost of steam.

Also, the blower will assist and thereby create more perfect combustion where draft is defective, increasing steaming capacity with same amount of fuel.

In case of emergency, the blower provides a means of forcing the boilers.

Write for Catalog 4-A.

SCHUTTE & KOERTING CO.

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1976-1911

The Fidelity and Casualty Co.

of New York.

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The Company grants insurances as follows:

FIDELITY BONDS	STEAM BOILER
EMPLOYERS' LIABILITY	ELEVATOR
PERSONAL ACCIDENT	FLYWHEEL
HEALTH	BURGLARY

PLATE GLASS

In the Fidelity, Boiler, Elevator, and Flywheel lines, careful inspections are made by experts.

Capital: $1,000,000 Surplus: $2,564,229.90

Amount Of All Losses Paid To Date, December 31, 1909: $31,636,503.21

The Prevention of Industrial Accidents.

The experience of this Company under its liability policies covering 25,000 accidents a year has been studied in order to determine what industrial accidents are preventable. From such data and from data gathered from other sources, we believe that fully sixty per cent. fall within the preventable class.

How these accidents may be prevented is told in a pamphlet of about 200 pages, prepared by us.

A first edition of thirty thousand copies has been exhausted. A copy has been sent without charge to each of the Company's industrial policy-holders. A second edition of twenty thousand copies is now in press.

The price to the public is nominal,—twenty-five cents. A copy will be sent upon receipt of remittance

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